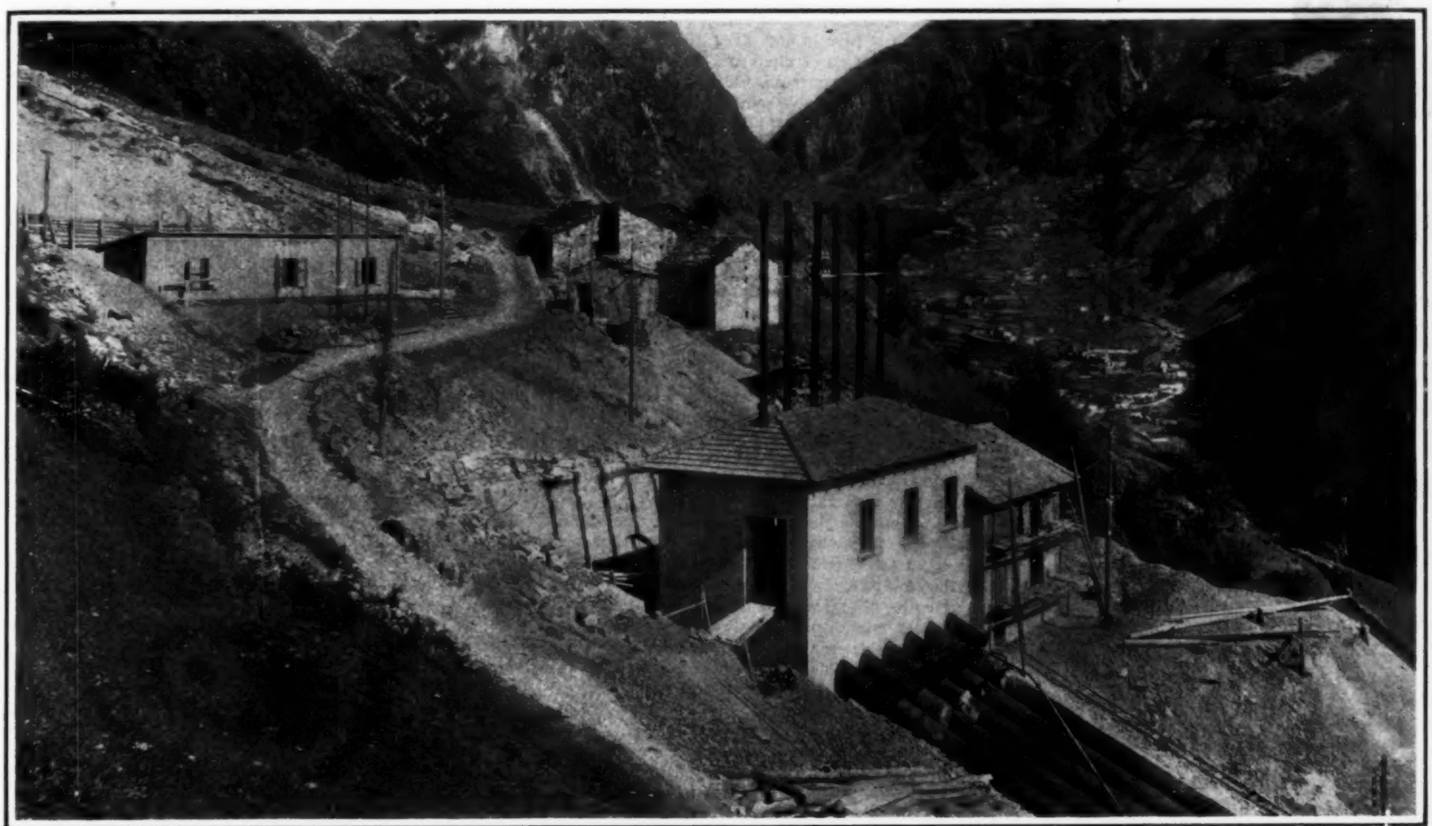
SCIENTIFIC AMERICAN SUPPLEMENT. No 1723

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1909, by Munn & Co.
Published weekly by Munn & Co. at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

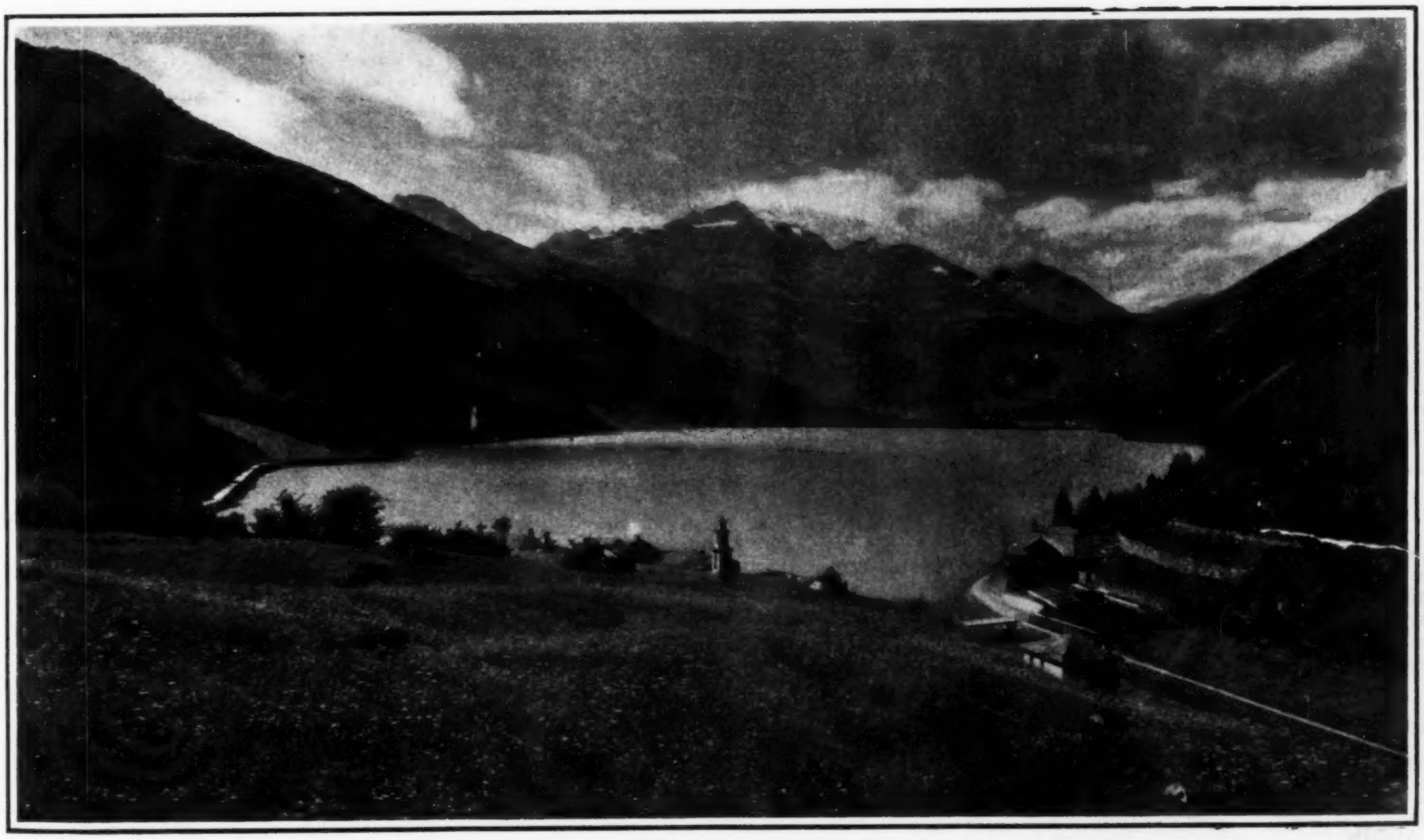
Scientific American, established 1845.
Scientific American Supplement, Vol. LXVII., No. 1723.

NEW YORK, JANUARY 9, 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



PENSTOCKS AND GATEHOUSE OF THE BRUSIO HYDRO-ELECTRIC POWER PLANT.



LAKE POSCHIAVO, NATURAL RESERVOIR OF THE BRUSIO-CAMPOCOLOGNA POWER PLANT.

A SWISS-ITALIAN 50,000-VOLT POWER-TRANSMISSION SYSTEM.—[See page 24.]

A BRIEF HISTORY OF WIRELESS TELEGRAPHY.*

MILESTONES IN THE EVOLUTION OF A NEW ART.

BY R. A. FESSENDEN.

IN preparing this note it has been considered best, for the sake of accuracy, to refer to published results, such as scientific articles or theses or patent specifications. For the sake of brevity, references to work done in repetition of previously published work has as a rule been omitted. So far as possible, the expression of personal opinion has been avoided in this section of the paper, the object being to gather together in concise form the facts known in regard to the development of the art. With the exception of Munk's original paper, which could not be obtained, all references have been verified by consulting the original publications.

Period 1838-1897. *Origin and Development of Old or Damped Wave-coherer Method.*—Joseph Henry, to whose work the development of wire telegraphy owes so much, was the first (1838-1842) to produce high-frequency electrical oscillations, and to point out and experimentally demonstrate the fact that the discharge of a condenser is under certain conditions oscillatory, or, as he puts it, consists "of a principal discharge in one direction and then several reflex actions backward and forward, each more feeble than the preceding until equilibrium is attained."[1]

This view was also later adopted by Helmholz[2], but the mathematical demonstration of the fact was first given by Lord Kelvin in his paper on "Transient Electric Currents."[3]

In 1870 Van Bezold discovered and experimentally demonstrated the fact that the advancing and reflected oscillations produced in conductors by a condenser discharge gave rise to interference phenomena.[4]

In 1883 Prof. Fitzgerald suggested at a British Association meeting[5] that electromagnetic waves could be generated by the discharge of a condenser, but the suggestion was not followed up, possibly because no means was known for detecting the waves.

Hertz[6] discovered a method of detecting such waves by means of a minute spark-gap and before March 30, 1888, had concluded his remarkable series of researches in which for the first time electromagnetic waves were actually produced by a spark-gap and radiating conductor and received and detected at a distance by a tuned receiving circuit.

Hertz changed the frequency of his radiated waves by altering the inductance or capacity of his radiating conductor or antenna, and reflected and focused the electromagnetic waves, thus demonstrating the correctness of Maxwell's electromagnetic theory of light.

Lodge later in the same year read a paper on the "Protection of Buildings from Lightning,"[7] before the Society of Arts, in which he described a number of interesting experiments on oscillatory discharges.

Great interest was excited by the experiments of Hertz, primarily on account of their immense scientific importance. It was not long, however, before several eminent scientists perceived that the property possessed by the Hertz waves of passing through fog and material obstacles made them particularly suitable for use for electric signaling.

Prof. Elihu Thomson in a lecture delivered at Lynn, Mass., on "Alternating Currents and Electric Waves," in 1889, suggested this use.

Sir William Crookes in the Fortnightly Review for February, 1892, discussed the matter in some detail. I quote his statement in full as it shows what a clear conception he had of the possibilities and obstacles to be overcome:

"Here is unfolded to us a new and astonishing world, one which it is hard to conceive should contain no possibilities of transmitting and receiving intelligence.

"Rays of light will not pierce through a wall, nor, as we know only too well, through a London fog. But the electrical vibrations of a yard or more in wave length of which I have spoken will easily pierce such medium, which to them will be transparent. Here, then, is revealed the bewildering possibility of telegraphy without wires, posts, cables, or any of our present costly appliances. Granted a few reasonable postulates, the whole thing comes well within the realms of possible fulfillment. At the present time experimentalists are able to generate electrical waves of any desired wave-length from a few feet upward, and to keep up a succession of such waves radiating into space in all directions. It is possible, too, with some of these rays, if not with all, to refract them through suitably shaped bodies acting as lenses, and so direct a sheaf of rays in any given direction; enormous lens-shaped masses of pitch and similar bodies have been used for this purpose. Also an experimentalist at a distance can receive some, if not all, of these rays on a properly constituted instrument, and by concerted signals messages in the Morse code can thus pass from one operator to another. What, therefore, remains to be discovered is—first, simpler and more certain means of generating electrical rays of any desired wave-length, from the shortest, say of a few feet in length, which will easily pass through buildings and fogs, to those long waves whose lengths are measured by tens, hundreds, and thousands of miles; secondly, more delicate receivers, which will respond to wave-lengths between certain defined limits and be silent to all others; thirdly, means of darting the sheaf of rays in any desired direction, whether by lenses or reflectors, by the help of which the sensitiveness of the receiver (apparently the most difficult of the problems to be solved) would not need to be so delicate as when the rays to be picked up are simply radiating into space in all directions, and fading away according to the law of inverse squares.

"I assume here that the progress of discovery would give instruments capable of adjustment by turning a screw or altering the length of a wire, so as to become receptive of wave-lengths of any preconcerted length. Thus, when adjusted to 50 yards, the transmitter might emit, and the receiver respond to, rays varying between 45 to 55 yards, and be silent to all others. Considering that there would be the whole range of waves to choose from, varying from a few feet to several thousand miles, there would be sufficient secrecy, for curiosity the most inveterate would surely recoil from the task of passing in review all the millions of possible wave-lengths on the remote chance of ultimately hitting on the particular wave-length employed by his friends whose correspondence he wished to tap. By 'coding' the message even this remote chance of surreptitious straying could be obviated.

"This is no mere dream of a visionary philosopher. All the requisites needed to bring it within the grasp of daily life are well within the possibilities of discovery, and are so reasonable and so clearly in the path of researches which are now being actively prosecuted in every capital of Europe that we may any day expect to hear that they have emerged from the realms of speculation into those of sober fact. Even now, indeed, telegraphing without wires is possible within a restricted radius of a few hundred yards, and some years ago I assisted at experiments where messages were transmitted from one part of a house to another without an intervening wire by almost the identical means here described."

The statement in the last paragraph of the quotation refers to the work of Prof. David E. Hughes.[8] Prof. Elihu Thomson and E. J. Houston in 1876 made a number of experiments and observations on high-frequency oscillatory discharges.[9]

Prof. Dolbear also suggested the same thing in an article in Donahoe's Magazine, March, 1893.

In fact the idea of using Hertzian waves for wireless telegraphy seems to have been quite widespread in the years immediately following Hertz's publications.

Fairly efficient means of generating electromagnetic waves of any desired length had been made known by Hertz. Vertical antennæ connected with the ground had been previously used for sending and receiving by Dolbear in 1882 in connection with his system for telegraphing by electrostatic induction[10] and also later by Edison and others.

Hertz's receiver, the minute spark-gap, was not suited for wireless telegraphy and before any telegraphic work could be done a suitable receiver had to be found.

The fact that tubes containing conducting powders had their resistance altered by the discharge of a Leyden jar and that the original resistance could be restored by tapping the tube was first noted by Munk in 1835.[11]

In 1890 Branly showed that such a tube would respond to sparks produced at a distance from it.[12]

In 1892, at the meeting of the British Association at Edinburgh, Prof. George Forbes suggested that such a tube would respond to Hertzian waves.

In 1893 Prof. Minchen demonstrated experimentally that such powders would respond to electromagnetic waves generated at a distance.[13] He used a battery and galvanometer shunted around the powder to detect the effect of the waves.

Sir Oliver J. Lodge on June 1, 1894, delivered a lecture before the Royal Institution.[14] In this lecture Lodge described among other things the following:

1. The filings coherer.
2. The filings coherer in hydrogen under reduced pressure (this in a note added July, 1894).
3. The automatic tapper back for the coherer.
4. The metallic reflector for focusing the waves.
5. The connection of the coherer to a grounded conductor; i. e., a gas pipe system.
6. The method of making the coherer so connected respond by setting up oscillations in a separate grounded system, i. e., a hot-water pipe system, in another part of the building.
7. The method of detecting distant thunder storms by connecting the coherer to a grounded gas pipe system.

In this lecture Prof. Lodge stated that in his estimate the apparatus used would respond to signals at a distance of half a mile.

Early in 1895 Prof. Popoff[15] of Cronstadt, Russia, constructed a very sensitive filings coherer, one form of which was used in some surveying experiments by the Russian government,[16] consisting of iron filings suspended by a magnet and resting upon a metallic plate or cup. He used early in 1895 the automatic tapping back mechanism, and substituted for the galvanometer an ordinary telegraphic relay. He operated this apparatus at a distance by means of a large Hertzian radiator. One terminal of his coherer was connected to a conductor fastened to a mast about 30 feet high on the top of the Institute building and the other terminal of the coherer was grounded.

At the conclusion of his paper, which is dated December, 1895, Popoff made the following statement: "In conclusion, I can express the hope that my apparatus, with further improvements of same, may be adapted to the transmission of signals at a distance by the aid of quick electric vibrations, as soon as the source of such vibrations, possessing sufficient energy, will be found."

Among other experimenters who were working on this subject at the same time may be mentioned Capt. Jackson of the British navy, and Mr. A. C. Brown.

Marconi, on June 2, 1896, filed a provisional specification[17] showing two forms of apparatus, one similar to Lodge's 1894 apparatus using ungrounded aerials for both sending and receiving and the other for use "when transmitting through the earth or water" substantially identical with Lodge's 1894 and Popoff's 1895 apparatus, with taper back, etc., and the receiving antenna only being grounded.

Soon after, in July, 1896, Marconi arrived in England and made a number of experiments for the English Post Office at Salisbury Plain and elsewhere, using ungrounded aerials and parabolic reflectors and succeeded in reaching nearly two miles.

On March 2, 1897, Marconi filed the complete specification in which was included a statement that the transmitting antenna also could be grounded.

Lodge filed a provisional specification[18] showing radiating spheres but no antenna on May 10, 1897. The complete specification filed on February 5, 1898, shows as one form both antennæ grounded and also the use of an inductance wound in the form of a coil for diminishing the rate of damping of the waves.

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[1] Scientific Writings of Joseph Henry, Smithsonian Institution.

[2] Helmholz "Erhaltung der Kraft," Berlin, 1847.

[3] Kelvin, Philosophical Magazine, June, 1853.

[4] Van Bezold, Poggendorff's Annalen, 140, p. 541.

[5] Fitzgerald "On a method of producing Electromagnetic Disturbances of comparatively short wave lengths." Report of British Association, 1883.

[6] Hertz "Electric Waves."

[7] Lodge Society of Arts, 1888.

[8] For Report of this work see Electrician, May 5, 1899.

[9] Journal Franklin Institute, April, 1876.

[10] Dolbear U. S. patent 350,299, March 24, 1882.

[11] See Guthe, "Coherer Action," Transactions of the International Electrical Congress, St. Louis, 1904, page 242.

[12] Branly, Comptes Rendus, 1890, page 785, and 1891, page 90.

[13] Minchen, Proceedings Physical Society, London 1893, page 455.

[14] Sir O. J. Lodge, "The Work of Hertz," Proceedings Royal Institution, June 1, 1904, vol. 14, page 321.

[15] Journal Russian Physico-Chemical Society, vol. 27, April 25, 1895.

[16] A. S. Popoff, "Apparatus for detection and registration of electrical vibrations," Journal Russian Physico-Chemical Society, vol. 28, December, 1895.

[17] Marconi, Great Britain patent, 12,039, 1896.

[18] Lodge, Great Britain, patent, 11,575, 1897.

So far as is known little work was done in America during this period. The writer made some experiments in 1896 and in conjunction with two of his students, Messrs. Bennett and Bradshaw, did considerable work on receivers of various types in the winter of 1896 and spring of 1897, the results of which were incorporated in a thesis.[19]

1898. *Return to First Principles and Foundation, on Lines Antithetical to Old, of New or Sustained Oscillation-non-microphonic Receiver Method.*—Up to the year 1898, as may be seen from the above, the development of wireless telegraphy had proceeded along a single line. In that year, however, an entirely new method of wireless telegraphy was developed, characterized by a return to first principles, the abandonment of the previously used methods and by the introduction of methods in almost every respect their exact antitheses.

While the coherer is of more or less interest theoretically it is not adapted for use for telegraphic purposes. Responding as it does to voltage rises above a certain limit it does not discriminate between impulses of different characters, and is therefore peculiarly susceptible to interfering signals and atmospheric disturbances, and the operation of coherer systems cannot be guaranteed during the summer months or in the tropics. Roughly speaking, a coherer acts by starting an arc and making a short-circuit on the line every time a signal is received, which short-circuit persists until it is broken by a blow from an additional mechanism, and such a method of operation is obviously far from practical. In addition it is practically impossible to obtain sharp tuning in a local circuit containing a coherer; its action is always more or less erratic, its electrostatic capacity variable, and it is insensitive.

At the sending end the energy which can be liberated by the discharge of an antenna is limited and in the form used prior to 1897 the dampening is so great that there are only a few oscillations per spark.

Lodge[20] by placing a coil of large inductance in the antenna throttled down the amount of energy radiated per oscillation and so obtained with the same limited amount of energy derived from the charged antenna, an increase in the time of dampening.

Braun[21] patented the method of using a local oscillatory circuit connected to an antenna, the local oscillatory circuit having a much longer period than the natural period of the antenna and of a different order of magnitude. Such a system, however, does not radiate energy appreciably, and produces a damped wave.

This dampening and the limited amount of energy obtainable by charging and discharging the antenna prevent sharp tuning and long-distance working.

The coherer is well adapted for working with damped waves, but the coherer-damped wave method can never be developed into a practical telegraph system. It is a question whether the invention of the coherer has not been on the whole a misfortune as tending to lead the development of the art astray into impracticable and futile lines and thereby retarding the development of a really practical system.

The fact that no coherer-damped wave system could ever be developed into a practically operative telegraph system, and the fact that it was necessary to return to first principles and initiate a new line of development along engineering rather than laboratory lines was perceived in America in 1898[22] and a new method was advised which may be called the Sustained Oscillation-non-microphonic Receiver method as opposed to the Damped Oscillation-coherer method.

Fundamental Differences Between the Old and New Wireless Schools.—The differences between the two methods are shown in tabulated form:

	Damped Oscillation-coherer Method.		Sustained Oscillation-non-microphonic Method.
A1:	Damped oscillations are produced at the sending end.	A1:	Sustained oscillations are produced at the sending end.
2:	The energy transmitted is obtained by charging the antenna and discharging it.	2:	The energy transmitted is derived from a local source and not from the antenna.
3:	A spark gap is used for producing the oscillations.	3:	An arc or high frequency dynamo is generally used for producing the oscillations.
B1:	Imperfect or microphonic contact receivers are used.	B1:	Non-microphonic contact receivers are used.
2:	The action of the receiver depends upon the voltage rise and is independent of the amount of energy received.	2:	The receiver response is determined by the integral amount of energy received.
3:	An open tuned circuit is used for receiving.	3:	A closed tuned circuit is used for receiving.
4:	The receiving circuit is tuned to the wave frequency only.	4:	The receiving circuit may be tuned to a group frequency as well as to the wave frequency.
C1:	In transmitting messages the production of the electromagnetic waves is intermittent.	C1:	The waves are preferably generated continuously and the transmission accomplished by changing the character of the wave.
2:	The wave energy flux is intermittent.	2:	The wave energy flux is constant.
3:	A high voltage is used.	3:	A low voltage is used.
4:	Comparatively short wave-lengths are used.	4:	Comparatively long wave-lengths are used.
5:	The signals consist of dots and dashes, whose interpretation is fixed.	5:	The signals may consist of dots only, whose interpretation depends on the station sending and receiving.
D1:	Antennæ are used adapted, roughly speaking, to utilize the electrostatic component of the electromagnetic waves.	D1:	The antennæ are preferably arranged so as to utilize the other component of the electromagnetic waves instead of the electrostatic component.

The history of these two antithetical lines of development will be treated of separately.

Period 1898-1902 A. *Development and Perfecting of Sustained Oscillation-non-microphonic Receiver Method* (a) *The current-operated receiver.*—The first essential for the development of the system was, of course, a quantitatively responsive receiver. Several forms of this were tried including the modification of the Boys radio-micrometer (consisting of a light thermo couple suspended in the field of a permanent magnet and heated by radiation from a wire which in turn was heated by the current to be detected) described by the writer at the Columbus meeting of the American Association in 1897.[23] This was abandoned in favor of Prof. Elihu Thomson's alternating-current galvanometer[24] suitably modified for telegraphic work.[25]

Among other forms of current-operated receiver may be mentioned the following:

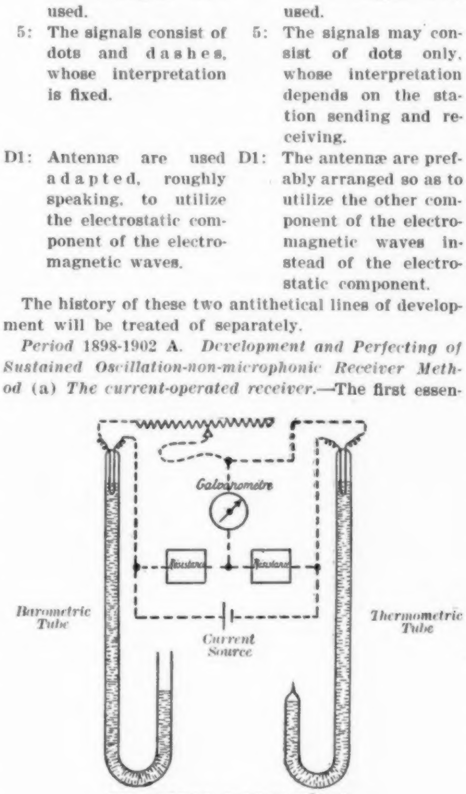
The *Hot-wire Barretter*,[26] consisting of a minute platinum wire a few hundred thousandths of an inch in diameter and approximately a hundredth of an inch in length. The term "barretter" was coined for this device for the reason that it differs essentially from the bolometer of Langley in that it is arranged to be affected by external sources of radiant heat as little as possible instead of as much as possible, and to have an extremely small specific heat, an object not sought in the case of the bolometer.

The *Liquid Barretter*,[27] in which the change of resistance is effected by heating a liquid, the concentration of path being obtained by means of a fine platinum wire point. Some question has been raised as to the theory of operation of this device, but I think there is no question but that the effect is due to heat, though what per cent of the effect is due to change in ohmic conductivity by heat and what per cent is due to depolarization by heat is still, as originally stated by the writer,[28] uncertain. The facts that the device operates practically equally well irrespective of which terminal is connected to the local battery, and that the effect varies as the square of the alternating current (as a heat operated device should do) instead of directly with the alternating current as a rectifier would do, and that depolarization is produced by the heat, have been confirmed by Dr. L. W. Austin.[29] The writer has experimentally determined the fact that though the electrical impulses may have a duration of less than a millionth part of a second the change in resistance persists for approximately the ten-thousandth part of a second, which would seem to show conclusively that the action is not a *direct* effect of the waves.

(To be continued.)

[19] Western University of Pennsylvania, May, 1897.
[20] Lodge, Great Britain, patent 11,575, 1897.
[21] Braun, German patent 11,578, October 14, 1898.
[22] Proceedings American Institute of Electrical Engineers, November, 1899, page 635, and November 20, 1906, page 781.
[23] Electrician, June 24, 1904.
[24] Elihu Thomson, U. S. patent 363,185, January 26, 1887.
[25] U. S. patents 706,736, and 706,737, December 15, 1899.
[26] U. S. patent 706,744, June 6, 1902.
[27] U. S. patent 727,331, April 9, 1903.
[28] Ibid.
[29] Austin, Bulletin of the Bureau of Standards, vol. 2, No. 2.

AN ELECTRIC BAROMETER.



ELECTRIC BAROMETER.

IN this barometer, which is described by Robert Goldschmidt, the variations in the height of a mercury column resulting from the changes of atmospheric pressure are caused to modify the resistance of a filament of low specific conductivity inserted in an electric circuit. A thin U-shaped carbon filament is fused into the closed end of a barometer tube and its terminals are connected to two binding posts on the outside of the tube. When the tube is filled with mercury, the curved part of the filament is more or less immersed in it, according to the atmospheric pressure to which the mercury column is subjected. The parallel branches of the filament traverse the vacuum of the barometer. The current passing through the two branches of the filament and the mercury meets with more or less resistance, accordingly as the mercury column is higher or lower. It is not sufficient, however, in order to obtain an indication of the changes in atmospheric pressure, to measure the variations of the total resistance of the carbon filament, as temperature changes also influence the level of the mercury column. This cause of error may be eliminated by using a second mercury column in a tube closed at both ends, in which the mercury level is influenced only by temperature changes of the surrounding medium. In this second tube, which operates as a thermometer, a carbon filament is arranged as in the first, and its resistance is modified by changes in the height of the mercury column. Thus, while the changes of resistance in the barometric tube correspond at the same time to variations of atmospheric pressure and temperature, the indications of the thermometric tube relate to temperature changes only. If the resistances composed of the two filaments are arranged in series like two branches of a Wheatstone bridge and compensated by resistances in the lower branch of the same bridge, a galvanometer connected in the usual manner across the bridge will remain at zero, when at an equal atmospheric pressure the temperature causes a change in the height of the mercury in both tubes at the same time. The relation of the compensating resistances will evidently vary according to the thickness of the filaments used in the tubes, their relative dimensions, and the changes of the mercury level produced by the same temperature variation in each tube. In order to indicate the variation of atmospheric pressure it is only necessary to insert in that branch of the bridge containing the thermometric filament, for instance, an adjustable resistance, such as a high-resistance wire mounted over a graduated scale, which, by means of a sliding contact, may be inserted more or less in the circuit. By regulating this resistance so that the galvanometer remains at zero, one adds to or takes from it exactly the same amount of resistance that has been added to or taken from the carbon filament in the barometric tube by variations of atmospheric pressure only. These variations are thus read on the graduated scale of the adjustable resistance. It is easy, by means of the arrangement described, to read variations of one-ten-thousandth of a millimeter in the height of the barometric mercury column. Curves obtained by means of this apparatus were found to correspond always with those at the Uccles Observatory.—Translated and abstracted from Bulletin Mensual, Société Belge d'Electriciens (Brussels) for Electrical Review.

The work of the Henry Draper Memorial, in the study and classification of stellar spectra, has disclosed a veritable mine of objects of unusual interest, and has added many new facts to our knowledge of the constitution and distribution of the stars. From an examination, by Mrs. Fleming, of plates obtained at Cambridge with the 8-inch Draper telescope, and at Arequipa, with the 24-inch Bruce and 8-inch Bache telescope, great additions to our lists of objects having peculiar spectra have been made. These include stars of the fourth type, the fifth type which consists mainly of bright lines, gaseous nebulæ, spectra in which one or more of the hydrogen lines are bright, several new stars, and variables having bright hydrogen lines in spectra of the third type. Lists of these objects have been announced, from time to time, in various scientific journals, and later in the Harvard circulars.

UTILIZING WASTE WOOD.*

DESTRUCTIVE DISTILLATION; THE RECOVERY OF TURPENTINE AND OTHER PRODUCTS.

BY F. P. VEITCH.

EACH year there are millions of cords of wood wasted in the forest and on the farm. This wood, because of its shape, size, or quality, is not suitable for the numerous mechanical uses for which wood is employed, and information regarding other means of disposing of this waste is of general interest. Aside from tanning and paper making, which are chemical industries that have been established for hundreds of years, there are other industrial uses, of more recent

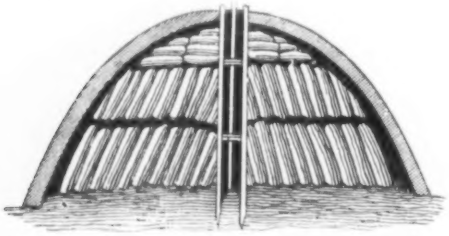


FIG. 1.—EARLY FORM OF KILN IN WHICH ONLY CHARCOAL IS RECOVERED.

origin, which are of agricultural importance because they offer a means of utilizing these wastes of the sawmill and the forest. The more important of these are destructive distillation, recovery of turpentine, rosin, and paper pulp, preparation of alcohols, and manufacture of acids. The growth of some of these industries has been rapid in recent years, and is not due alone to the demand for a method of utilizing the waste woods of lumbering operations, such as tops, sawdust, slabs, and timber too small to be profitably handled for lumber, but also to a steadily increasing demand for wood alcohol, acetates, acetone, turpen-

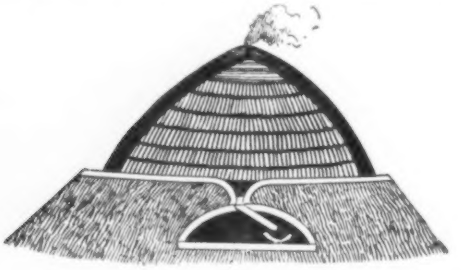


FIG. 2.—EARLY FORM OF KILN IN WHICH CHARCOAL AND TAR ARE RECOVERED.

tine, charcoal, etc., in other industries. In the past the demand for these products has been sufficient to encourage the steady growth of the industries engaged in their production, and the values of the products have been well maintained, except in so far as the passage of the law permitting the tax-free use of denatured alcohol has affected the price of wood alcohol.

Methyl alcohol, acetates, acetone, charcoal, turpentine, wood oil, and oxalic acid are directly or indirectly obtained on a commercial scale from woods, and the yield is governed largely by the specific grav-

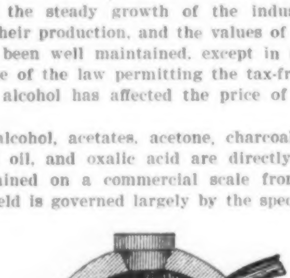


FIG. 3.—EARLY KILN FOR RECOVERY OF ALCOHOL AND ACID.

ity, weight per cord, and kind of wood, as well as by the manner in which the manufacturing process is conducted. Many other farm products, such as sugar cane, cornstalks, straws, cotton stalks, etc., will yield these products, and it is possible that many other wastes may in the future be utilized in this way. So far, however, but little attention has been given to these materials, and for economic reasons they are not commercially employed.

Different kinds of wood have different specific gravities, and even samples of the same species differ in this respect. The weight of a cord of wood varies

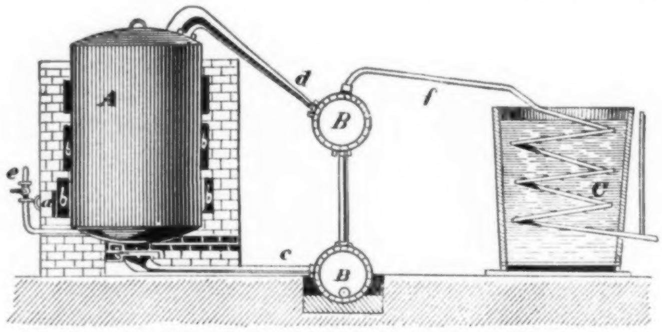


FIG. 4.—SWEDISH THERMO-KETTLE.

A. Retort. a. Furnace. b. Spiral flue. c. Tar pipe. d. Neck conducting the gases. B. Drums where tar vapors condense and collect. C. Condenser. e. Steam pipe. f. Pipe conducting acid vapors to condenser.

not only with the specific gravity of the wood but also with the way in which it is piled, a closely piled cord weighing, of course, more than a loosely piled one. It has been found that as a rule there is 44 per cent of vacant space in a cord of wood as usually put up, but 56 per cent of the 128 cubic feet being actually wood.

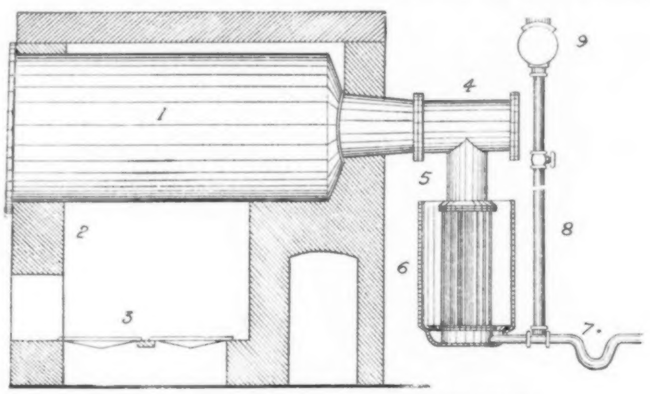


FIG. 5.—ROUND RETORT WITH CONDENSER.

1. Retort. 2. Fire walls. 3. Grate. 4. Neck. 5. Pipe to condenser. 6. Condenser. 7. Trapped delivery pipe. 8. Gas pipe. 9. Gas main.

The wood used for destructive distillation should be as dry as possible, as much time and fuel are wasted if green or wet wood must be dried in the retort and the temperature raised under such conditions to the point at which distillation begins. For these reasons it is the best practice to cut and stack the green wood, which contains from 20 to 50 per cent of water, from eight months to two years before it is to be used, in order that it may become well seasoned. Even seasoned woods contain from 12 to 25 per cent of water, which must be evaporated in the retort before the disintegration of the wood begins.

The capital required to maintain a two years' supply of wood for a plant using 20 cords of wood a day varies from $20,000 to $40,000, so that in many instances wood not thoroughly seasoned is used in preference to making this outlay. Such a practice, of course, increases the operating expenses considerably, and drying ovens heated by the waste steam and gases of the plant have been used in some cases to dry the wood quickly before it goes into the retort. This is undoubtedly the better practice, and whenever it is possible plants should be equipped with such drying ovens, thus decreasing the amount of capital invested in wood and at the same time securing large yields, as during seasoning by exposure wood loses weight from rotting and from the solution of water-soluble constituents, and consequently gives a lower yield of distillation products.

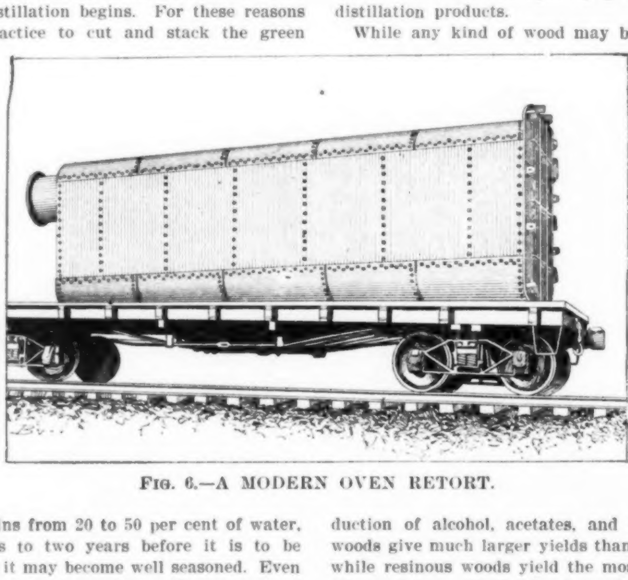


FIG. 6.—A MODERN OVEN RETORT.

While any kind of wood may be used for the production of alcohol, acetates, and charcoal, the hard woods give much larger yields than do the soft woods, while resinous woods yield the most turpentine, wood oils, and tar. Of the hard woods the maple, birch, beech, and oak are preferred although other woods, such as poplar, elm, willow, aspen, and particularly

* Abstracted from a bulletin issued by the United States Department of Agriculture.

alder, give nearly as high yields. The quantities of the several products obtained in modern plants from one cord of wood are shown in the following table:

AMOUNT OF PRODUCTS YIELDED PER CORD OF WOOD.

Class of Woods	Charcoal, Bushels.	Alcohol (Crude) Containing Acetone, Gallons.	Acetate of Lime, Pounds.	Tar, Gallons.	Wood Oils, Gallons.	Turpentine, Gallons.
Hardwoods	40 to 50	8 to 12	150 to 200	8 to 20	......	......
Resinous woods	25 to 40	2 to 4	50 to 100	30 to 60	30 to 60	[1] 12 to 25 [2] 2 to 10
Sawdust (hardwood).......	25 to 35	2 to 4	45 to 75	....	....	....

[1] Lightwood. [2] Sawdust.

The wide variations in quantity obtained from the same class of materials are due to differences in quality and weight of the wood used and also to different methods of conducting the distillation. The low yield obtained from sawdust is rather surprising, and is probably explained by the packing of the material in the retorts, owing to which fact complete decomposition is rarely obtained. As far as can be learned, no satisfactory process has yet been devised for distilling sawdust.

The apparatus required for the destructive distillation of wood consists of (1) retorts or ovens, in which the distillation is carried on and the chief chemical reactions involved in the production of the crude products take place; (2) condensers, in which the condensable vapors are liquefied; (3) stills, in which the crude products are separated, concentrated, and purified; (4) mixing pans for the preparation of acetate of lime, and (5) general apparatus, such as evaporating pans, storage tanks, coolers, pumps, etc.

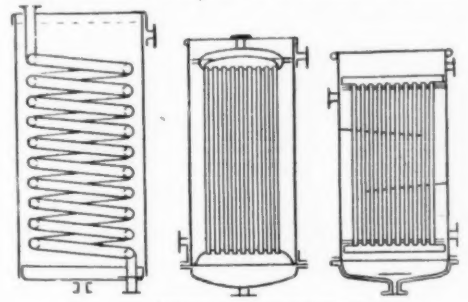


FIG. 7.—TYPES OF CONDENSERS.

The various forms of kilns in which wood was formerly charred are of historic interest especially in connection with the modern improved retorts; but as the yield of alcohol and acetate is very low even in the best kilns, these old forms are now employed only in localities producing charcoal iron, where charcoal is practically the only product recovered. Figs. 1, 2, and 3 illustrate these early forms of kilns. The yield of condensed products in a kiln, such as is shown in Fig. 3, is about one-half that from a modern retort.

When attempts were made to recover and condense the volatile products an air-tight iron retort (Fig. 4), known as the "Swedish thermo-kettle," set in brickwork and connected with a condenser, was devised and is still quite extensively employed abroad, where it has been in use since 1857. The round retort (Fig. 5), which is a modified and later form of the above, is made of three-eighths inch steel, is 9 feet long and 50 inches in diameter, and is provided with a large, tightly fitting door at one end and an outlet pipe, about 15 inches in diameter, connected with the condenser at the other end. The retorts are preferably set horizontally in pairs in brickwork, and batteries of from 6 to 16 pairs are common. The chief objection to this form of retort is that, as usually built, it must be filled and emptied by hand, thus making the cost of operating high. To obviate this objection, what is known as the oven retort (Fig. 6) was devised and in recent years has been largely used in equipping new plants for hardwood distillation. These retorts are rectangular iron chambers, a common size being 6 feet wide, 7 feet high, and from 27 to 50 feet long, according as they are intended to hold two or more cars loaded with wood. The ovens are set in brickwork, or are made with double iron walls with an air space between. They are provided with large doors closing airtight and are heated by wood, charcoal, coal, or gas.

The plant may be assembled and arranged in any desired manner, but it is highly desirable that full advantage be taken of natural conditions, that as

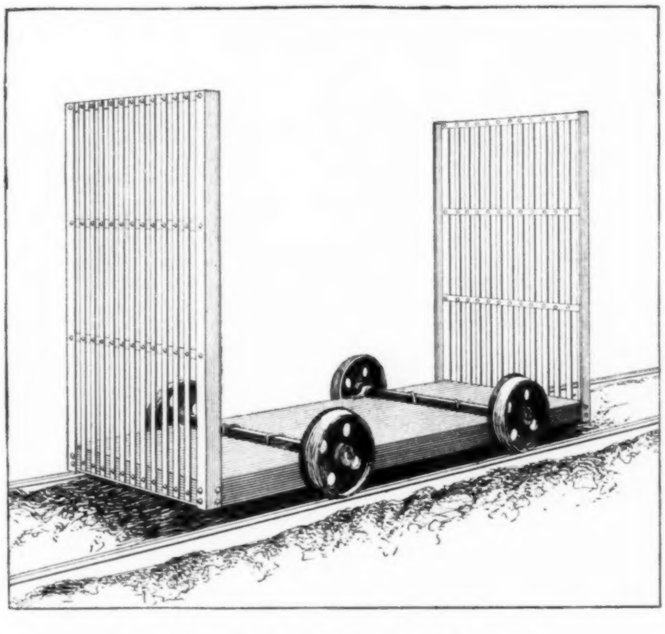


FIG. 8.—WOOD CAR USED IN OVEN RETORT.

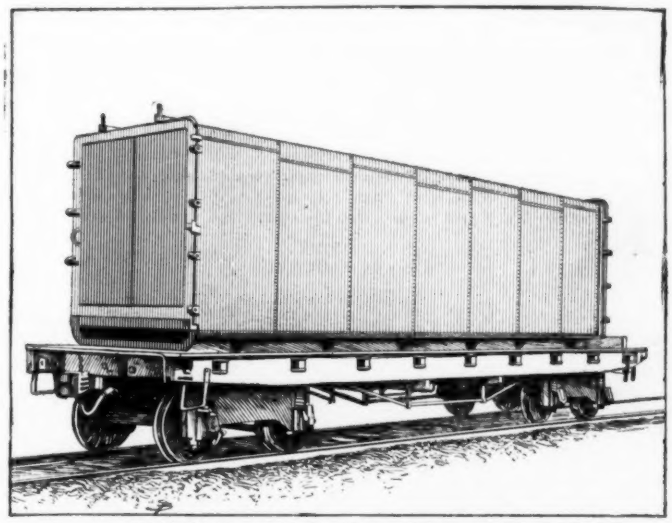


FIG. 9.—CHARCOAL COOLER USED WITH OVEN RETORT.

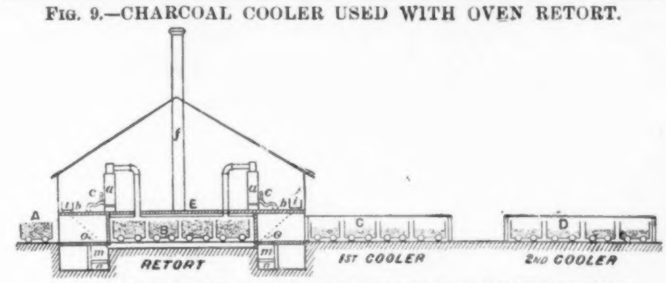


FIG. 10.—PLAN OF A MODERN AMERICAN DESTRUCTIVE DISTILLATION PLANT.

A. Car. B. Retort. C. First cooler. D. Second cooler. E. Acetate drying floor. a. Condensers. b. Liquor trough. c. Gas main to boilers. f. Fuel conveyer. m. Fire place. n. Ash pit. o. Hinged spout delivering fuel from f to m.

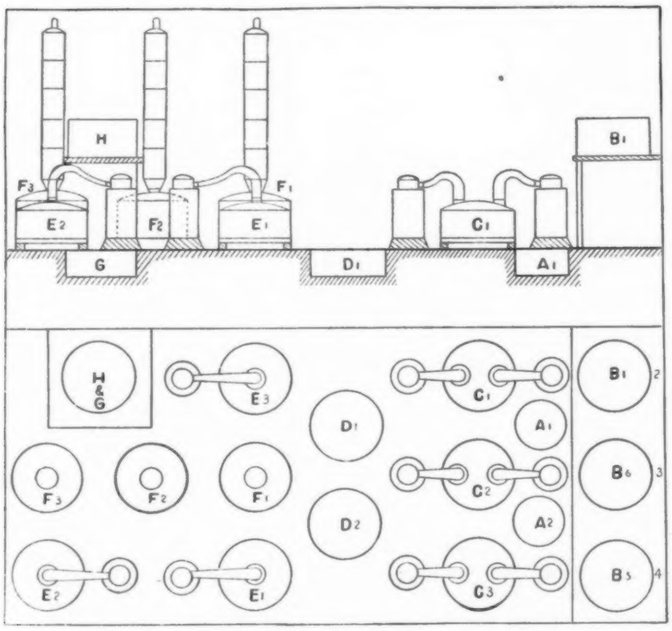


FIG. 11.—PLAN OF A REFINING APPARATUS.

A 1-2. Raw liquor vats. B 1-6. Raw liquor settling tanks. C 1. Tar still. C 2-3. Raw liquor stills. D 1-2. Neutralizing vats. E 1-3. Lime-lee stills. F 1-3. Alcohol stills. G. Weak alcohol storage tank. H. Strong alcohol storage tank.

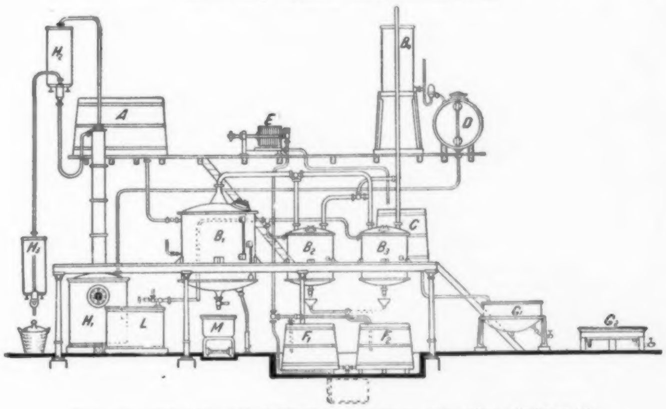


FIG. 12.—PLAN OF GERMAN TYPE OF FRACTIONAL DISTILLATION PLANT.

A. Reservoir for settling pyroligneous acid. B_1. Tar still. B_2, B_3. Liming stills. *C*. Vat for filtered acetate liquor. *D*. Reservoir for crude dilute alcohol. *E*. Filter press for acetate liquor. F_1, F_2. Vats for unfiltered acetate liquor. G_1, G_2. Evaporating pans for acetate. H_1, H_2, H_3. Column rectifying still for concentrating alcohol. *L*. Milk of lime vat. *M*. Boiled-tar car.

much labor as possible be performed by machinery, and that the whole establishment be conducted under the most rigid control, in order that the plant may be profitably worked and losses at any point quickly discovered. Modern plants are equipped with either the round or oven retorts. Figs. 10, 11, and 12 show arrangements of such plants as found in American and German practice.

The condensers (Fig. 7) are of the greatest importance; they should be sufficiently large to condense all the products even under the most adverse conditions, as material lost at this stage can never be recovered. For separating the constituents of the distillate a simple still, such as is used in the preparation of distilled liquors, may be used, although an iron still is generally preferred in distilling the alcohol and acetone from the acetate of lime. For tar storage and settling tanks it is customary to use wood; all pipes, pumps, and other apparatus through which the acid liquors pass must be of copper or wood.

Builders of destructive-distillation plants quote from $1,500 to $2,000 per day-cord on a basis of a 10-cord plant, with higher figures for smaller plants and lower figures for larger ones. The price of equipment when turpentine alone is recovered by distilling with steam is, as a rule, considerably lower than the destructive equipment, and quotations vary from $400 to $1,500 per cord of wood treated daily. These wide differences are due largely to the newness of the industry in the South, to differences in time of distillation, and also to the fact that in nearly all cases the apparatus is patented and an exorbitant value is frequently placed on the patent rights.

Round retorts are filled with the wood by hand, two lengths of wood filling a retort, which is made to hold about 1 cord. When ovens are used the wood is loaded on iron cars (Fig. 8) holding from 1 to 3 cords of wood, and from 2 to 8 cars are run into the oven. The doors in all cases are made gastight, if possible. The retorts are heated slowly and the distillation is continued for from twenty to thirty hours, the progress being indicated by the flow of liquor and the gradual heating of the front of the retort from top to bottom. When the entire front of the retort has reached a fairly uniform temperature the fires are allowed to die down, and, when the retorts or ovens are sufficiently cool, the charcoal is removed.

If retorts are used the charcoal is placed in covered cans, but with ovens, coolers (Fig. 9), similar in shape, are used in which the coal is allowed to remain until thoroughly cool. The time required for distillation averages about twenty-four hours. The distillate from the retorts passes to the condensers (Figs. 5 and 7), where the acid, alcohol, and other valuable constituents are condensed to liquid form and then carried to a large wooden settling tank, which may be either underground or overhead, where it is allowed to stand for several days in order that the tar may settle. The uncondensed gases pass from the condensers to the gas mains (Figs. 5 and 10) and are either carried directly to the furnace and burned there or go to a gas holder, from which they are used. If the tar is not otherwise treated it is blown under the boilers with a steam jet and burned. Figs. 10, 11, and 12 show the general arrangement of plants. The separation and purification of the products will be described under the several products.

When hardwood is heated decomposition does not begin until the temperature has reached 150 deg. C. (302 deg. F.), the loss below this temperature being water alone. With resinous woods turpentine begins to distill with water at 97 deg. C. (207 deg. F.) and continues to pass up to about 185 deg. C. (365 deg. F.), overlapping with such products of destructive distillation as may begin to pass over above 150 deg. C. Above this temperature (150 deg.) liquid products resulting from the decomposition of the wood are distilled.

Distillation is, for all practical purposes, complete at 430 deg. C. (806 deg. F.), as the additional volatilization above this temperature is only about 1.5 per cent. The chief products are formed continuously throughout the entire process, which proceeds in three characteristic periods: (1) At a temperature from 150 deg. C. (302 deg. F.) to 280 deg. C. (536 deg. F.), acetic acid, methyl alcohol, and wood creosote are the chief products; (2) from 280 deg. to 350 deg. C. (662 deg. F.), large volumes of gases are also given off; (3) and from 350 deg. to 430 deg. C., solid hydrocarbons are distilled.

Experiments and experience have both shown a lower yield of acid and alcohol when the wood was rapidly heated than when slowly heated, but experiments also show that maximum yields of both products may be obtained even when distillation is completed in two or three hours. It appears, therefore, that the low yields obtained from fast heating in practice are due to overheating rather than to rapid heating. In the case of overheating, secondary reactions are set up by the high heat, resulting in the destruction of some of the alcohol and acid. This is particularly liable to occur where no provision has been made to remove the products of distillation from the influence of high heat. Further, when the vapors are evolved rapidly without provision for their prompt removal there is apt to be considerable loss from "blowing of the retorts," that is, the escape of gases around the door due to pressure within the retort. On the other hand, slow distilling allows the vapors to pass out with less loss from blowing or secondary reactions. It is of the greatest importance, therefore, that provisions be made for the rapid removal of the vapors from the retort and for their complete condensation subsequently.

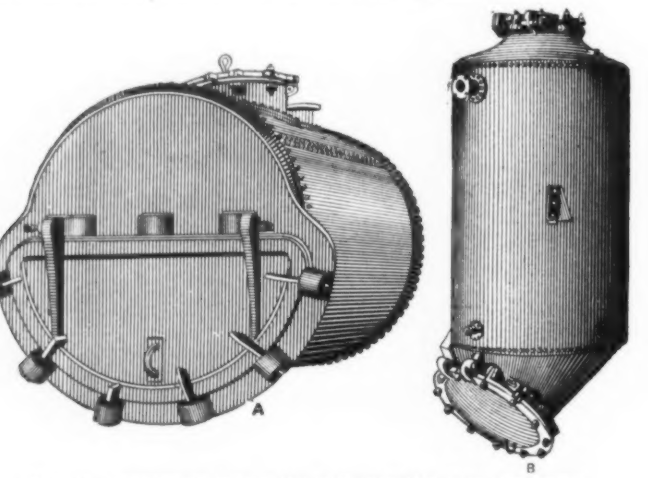


FIG. 13.—RETORTS USED IN DISTILLING TURPENTINE.

A. Horizontal type. B. Vertical type.

As pine, fir, and spruce contain turpentine and rosin, the process of distillation is modified when these woods are used. Fig. 13 shows some special forms of retorts for distilling pine. The processes in use are of two general types: Steam distillation and destructive distillation. In the former case live or superheated steam is used to remove the turpentine, which is the only product commercially obtained. During the heating part of the rosin oozes out of the wood but is seldom recovered. When the destructive process is employed the procedure differs from hardwood distillation only in the fact that the temperature in the retorts should be kept below 200 deg. C. (392 deg. F.) until the turpentine has been driven off, the aim being to keep the turpentine separated from the other products of distillation from which it can not be completely purified if they be allowed to mix. So far this has not been satisfactorily accomplished on an industrial scale owing to the difficulty of preventing local overheating of the retort.

A great number of retorts both for steam and destructive distillation of resinous woods have been invented and patented to meet the special conditions arising in distilling these woods. Many of these have valuable features, while others have no practical advantage over the regular hardwood retorts which have been in use for many years. The yield of turpentine will depend on the richness of the wood, ordinary pine yielding by steam distillation from 2 to 5 gallons per cord, while good light wood yields from 10 to 20 gallons and averages about 15 gallons per cord, and very rich light wood from 20 to 30 gallons. When pine is destructively distilled the yields from good light wood are as follows: Alcohol, from 1½ to 4 gallons; acetate of lime, from 50 to 100 pounds; turpentine, from 15 to 25 gallons; tar, 30 to 60 gallons; charcoal, 25 to 35 bushels; and other wood oils, 30 to 60 gallons. Very few operators recover the acetic [illegible] in any form and so far as is known none of them recover alcohol.

There is one other type of process applicable to the treatment of resinous woods and a few plants have been built to operate on this principle. The wood is treated, in a closed bath connected with a condenser, with a liquid having as high a boiling point as rosin, such as rosin itself, cotton seed oil, etc. Such a process is applicable for the recovery of the turpentine and rosin and industrially depends, of course, on the use of a solvent cheap enough to make it a financial success.

With reference to the wood turpentine industry in the South it may be said that, from a careful examination of a large number of plants, the writer is convinced that the distillation industry of the South can not be profitable as a whole until fundamental changes in equipment and in technical and business management are made. In the vast majority of cases the equipment is extremely crude, technical knowledge is lacking, and wasteful labor and business conditions prevail. Both profits and yields of products could be materially increased by improvements in all of these particulars.

(To be concluded.)

APPARENT DECAY OF RADIUM.

By SIR WILLIAM RAMSAY.

I WISH to put on record an observation relating to the amount of "electrolytic gas" obtainable from a solution of radium bromide. Some four years ago, about 172 milligrammes of radium salts of which 152 were bromide and 10 sulphate, were inclosed in four small bulbs along with water, which dissolved the bromide, and in which the sulphate was suspended. These bulbs were sealed to a small Töpler pump, and for three years the mixed oxygen and hydrogen gases were pumped off at short intervals—about four days between two extractions. With the emanation accompanying this mixture various experiments were performed, an account of which has appeared in the Proceedings of the Royal Society and the Transactions of the Chemical Society.

In November, 1907, I received from the Vienna Academy what was supposed to be 0.5 gramme of pure radium bromide; I was told that that was its weight in 1905. It weighed on receipt only 0.288 gramme. This substance was washed into a bulb, and sealed to the pump, along with the other bulbs. The amount of gas collected from the larger quantity, however, did not appear to be proportional to its greater weight, and as analysis of a sample showed that it consisted largely of carbonate, insoluble in water, it was resolved to convert the carbonate into bromide by introducing into the bulb with a pipette some pure hydrobromic acid. (I may mention, parenthetically, that the small sample, converted into bromide, gained in weight to such an extent as to show that the original amount must have weighed 0.4971 gramme, as $RdBr_2.2H_2O$.) The gas pumped off after this addition of hydrobromic acid contained much free bromine, but after a few weeks the evolution of bromine ceased, and "electrolytic gas" was produced to the amount of about 30 cubic centimeters a week, always mixed with a small excess of hydrogen. This regular evolution continued from February until November 11. On that day the usual 30 cubic centimeters of gas were pumped off; I have a note that "an unusually small quantity of hydrogen remained after explosion." On November 18 the gas was again pumped off; the quantity was approximately 13 cubic centimeters. Although it appeared unlikely that the tubes and taps should have been blocked, it was still possible. On November 25 the gas was again removed; its volume was about 1.5 cubic centimeter. At this stage air was admitted into the pump and the connected bulbs, and it was proved that there had been no stoppage. Advantage was taken of this to clean the pump and the connecting tubes, and to regrease the stopcocks. The air was then removed completely by pumping. To-day (November 30) the gas was again pumped off; its volume was about 0.5 cubic centimeter. It still exploded, and left about half its volume of excess hydrogen.

Two alternative suppositions suggest themselves: either the radium bromide, of which the apparatus contains 0.5071 gramme, implying 0.2716 gramme of metallic radium, has practically ceased to decompose water (about 25 cubic centimeters of solution are present in the bulbs), or the reverse reaction, viz., the velocity of combination of oxygen and hydrogen to form water, has increased to such an extent as to reverse the decomposition.

It has been assumed that the life-period of radium is very long, say 2,000 years, although Mr. Cameron and I, by measuring what we believe to be the true volume of the emanation, arrived at a considerably shorter period. Here, however, appears to be, on the first alternative, a proof that one of the ways in which radium expends at least a portion of its energy has been stopped. It would be interesting to know if the other ways, say the evolution of heat or the emission [illegible]" are similarly affected by time.—Nature.

SOME PROBLEMS OF THE MOTOR CAR.*

WHAT THE INVENTOR CAN DO FOR THE AUTOMOBILE.

EVER since 1903 marvelous progress has been made, and most of the difficulties of the engine, clutch change-gear and transmission have been met with such success that the flexible and smooth-running car of to-day appears to many so desirable as to present no further problems for the energy of the automobile engineer.

To others the present cars appear to embody only partial solutions of many problems. The clutch, for example, even in its best form, is a contrivance which should be abhorrent to the soul of the mechanic. It is a practicable mechanism, no doubt, which causes less damage to transmission gear than would be expected, but this is largely due to the excellence of the material of the modern car and the intelligence of most car drivers.

It has long seemed to me possible to design a pneumatic clutch connecting the engine and the driven shaft, so that no violent shocks could reach the transmitting mechanism. Such a clutch would consist essentially of two or more cylinders mounted on the end of the driven shaft and rotating with it, and a crank on the end of the engine-shaft connected to two or more pistons working in the rotating cylinders.

Change-speed gear also seems to be a very inferior mechanical device for varying the effort made possible to the road wheel. This has been much felt by motor car designers, and perhaps more mechanical ingenuity has been expended by them on various methods of getting a wide range of intensity of wheel effort without changing gear than on any other part of car mechanism. The system of gear-changing by sliding toothed wheels, notwithstanding its apparent mechanical crudity, has proved to be the principal survivor in the struggle, and its efficiency of action has certainly been greatly improved. If we must have gear changed at all, the quiet and easy gear-change of to-day leaves little to be desired.

Other efforts have been directed to the improvement of the gasoline engine itself, with the object of dispensing with change of gear ratio as much as possible, and accordingly this mode of development has produced the moderately high-power car of to-day, with its direct drive, live axle, and highly flexible engine. Success in this direction requires an engine capable of giving the maximum torque required by the road wheels on steep hills while geared on the direct drive, and, of course, it involves a powerful engine which runs at a very light load at customary speed on the level. For the greater part of its running, the engine will be only developing about one-fourth of its maximum power in order that the full power may be available for hill-climbing, without requiring change of gear. The necessity of carrying about this heavy and powerful engine, for but a small use of its full power, has been justly recognized as a disadvantage, and many methods have been devised for temporarily increasing the driving torque to be obtained from a small engine. Such methods include: The gasoline electric car, in which an accumulator supplies an electric motor, giving power to the driving shaft when the resistance to motion increases sufficiently, and the electric motor acts as a dynamo, and charges the accumulator when the engine is running under conditions of lighter load, and proposed air-reservoir cars, having pumps to fill up the reservoir, which, in turn, assist the engine when required.

Other inventors seek to increase torque by providing air pumps supplying the air and gasoline charge to the engine under a pressure above that of the atmosphere. Daimler was the first to propose this, and he has been followed by many, including Mr. Dawson and Mr. O'Gorman. They, however, require a heavier engine to withstand the higher maximum pressure of explosion; and although the cylinder dimensions remain small in reality, the weight of the engine, to provide the same margin of safety, requires to be increased, as much as it would be by using larger cylinders.

So far attempts to increase the torque of a small power light engine have failed; it is very desirable, however, to persevere, as it appears probable that a much better type of car is possible, and many advantages to the public would follow success.

I have made experiments with super-compression devices of different kinds, which convince me that it is possible to arrange for the increase of the mean pressure upon the piston at the slower speeds of rotation by about 50 per cent without increase of maximum explosion pressure. To do this it is necessary not only to increase the charge supply pressure as proposed by Daimler, but also to increase the volume of the compression space. By the simultaneous increase of charge pressure and compression space volume, torque is greatly increased, although, of course, expansion is diminished, and the theoretical economy is somewhat reduced. My experiments have been made on relatively large gas engines, two engines of 22-inch cylinder diameter, one of 10-inch diameter, and another of 7-inch diameter, but the reasoning applies to small gasoline engine cylinders. Such an increase of mean pressure as I have suggested would enable cars of moderate power to dispense almost entirely with change of speed gear. My present car, for example, would be able to climb all the hills in my district without changing from the direct drive on the third speed.

If the pumping arrangements could be operated by a small separate gasoline motor, nicely balanced and always running, the main engine could be arranged to act as a compressed air engine only when in traffic or on hills at slow speed. The added engine and pumps increase the complication, but it seems to me possible to reduce total weight by the reduction of main engine dimensions and the simplification of gear-box arrangement. A car which could be stopped and started in traffic without the need of the clutch, and could stop on a steep hill in the same way, with the certainty of starting smoothly, would combine the advantages of both steam and gasoline engines.

Recent improvements in the gasoline engine, such as very large inlet and exhaust valves and very light pistons and moving connections, have made it possible to greatly increase the total power to be obtained from cylinders of given dimensions by permitting of longer strokes and higher speeds of rotation, while keeping up the weight of charge dealt with per stroke.

The famous 4-inch race has shown it to be possible to get about 60 indicated horse-power from a four-cylinder engine having 4-inch diameter cylinders, at a speed of about 2,000 revolutions per minute. The interesting new Daimler-Knight engine, in which lift-valves are replaced by sliding piston-ring sleeves, admits a larger charge at high speeds than is usual with ordinary valves, and so secures greater power for given cylinder dimensions.

I look forward with much interest to the coming year's experience with this fascinating form of gasoline engine.

All these improvements increase the power of control, but not the flexibility.

While even better results may be desired on the two points—clutch connection and true flexibility—another important matter requires persevering attention. I refer to the exhaust products discharged into the air of our streets; the rapidly increasing use of private and public motor cars in cities raises the study of the carbureter to a position of national importance.

It has been clearly proved that the product discharged from an engine when the mixture of gasoline and air is properly proportioned is innocuous in its chemical nature; combustion is almost complete; but when proportion is incorrect, and vaporizing action imperfect, the products are noxious. Carbureters present proportion correctly at two or at most three points of load and speed; at intermediate points some deviation occurs.

The problem of proportioning accurately and automatically for all speeds and loads is one of great difficulty, and existing devices provide an imperfect solution. It cannot be too firmly borne in mind that a mixture of constant composition is required at low and high speeds and low and high loads.

Methods of carbureter control which depend entirely on engine speed cannot produce accurate results, because the engine may run at the same speed under quite different conditions of throttle opening. What is really required is some method of controlling depending solely on the charge volume which passes the jet.

A practically successful method capable of meeting all the conditions has still to be designed.

* Abstract of the Presidential address by Dugald Clerk, M. Inst. C.E., before the Incorporated Institution of Automobile Engineers.

TWO INTERESTING SIPHON EXPERIMENTS.

Two interesting lecture demonstrations are described by Will C. Baker in a recent issue of School Science and Mathematics. They both teach siphon action; the first one is shown to the class by the aid of a lantern. The experimental arrangement is shown in Fig. 1, where the dotted circle indicates the condensing lens of the lantern. *A* and *B* are two small beakers at different levels, containing water. Into these is placed an inverted U tube having a branch at the top as shown. A piece of rubber tubing *E* a couple of feet long (with a spring clip at *D*) enables the operator to draw the water into the tubes as in a "Hare's hydrometer." The demonstration is as follows: (*a*) Draw the water halfway up the tubes as shown in Fig. 1. Call attention to the fact that the water levels in the tubes are each at the same height above their respective reservoirs; but that the difference in level of the reservoirs produces a difference in level in the tubes. (*b*) Draw the water up until it just flows over the bend and trickles down into the other leg of the tube. In this state the mechanism of the transference of fluid is apparent. The atmospheric pressure tends to support water columns of the same height in each tube, but as one reservoir is higher than the other a flow obtains. (*c*) Finally the water is drawn up to *L*, and the siphon acts quickly.

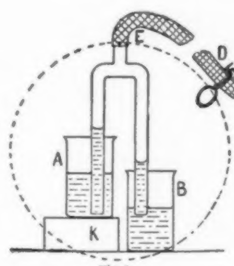


Fig. 1.

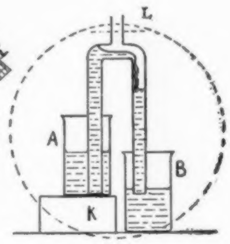


Fig. 2.

After the two reservoirs have come to the same level the removal of the block *K* starts the action in the opposite direction. By alternately inserting and withdrawing *K*, the siphon may be kept in action as long as desired. Hardwood sawdust or a pinch of black pepper in the water provides particles that are carried along by the current and indicate the flow to the class. Detailed explanation will suggest itself to any teacher.

The second experiment is to show the limit of siphon action. This experiment is seldom performed in class except in the case of the mercury siphon under the air pump. But this is not suitable for large classes and the following disposition has been found preferable:

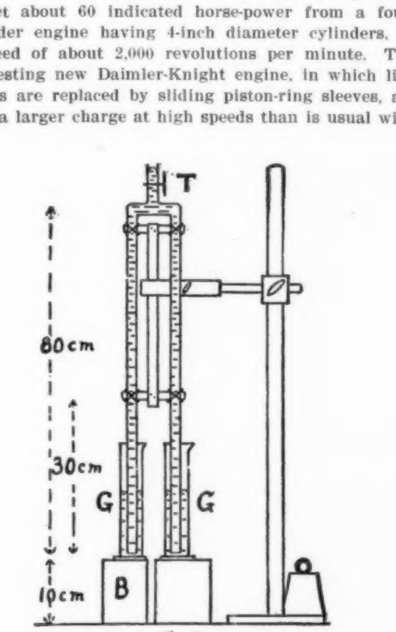


Fig. 3

A tube of the form and dimensions shown in Fig. 3 has a well-fitting tap at *T* and is bound to a light wooden frame. Two glass cylinders *GG* (graduated tubes) are filled about eleven centimeters deep with mercury and are set on blocks that hold them about ten centimeters above the lecture table. The siphon is held in a stand at such a height that the open ends of the legs are nearly touching the bottoms of the graduates, as shown. A water pump is connected to the end above *T*, and the mercury drawn up as far as possible. The whole system is then tipped forward until the mercury fills the whole tube below *T*. When the apparatus is again set upright (and the pump disconnected), the mercury fills the whole tube below *T*. On removing the block *B* and letting the graduate stand on the table, a very rapid siphoning takes place. On replacing the block, the action reverses. If both blocks be removed the siphon will not act, as the bend is now about seventy-nine centimeters above the level of the reservoirs. Thus the limit of siphoning, in the case of mercury, is actually demonstrated before the class. The comments to the class during these operations are obvious.

A 50,000-VOLT TRANSMISSION SYSTEM.

THE LARGEST HYDRO-ELECTRIC PLANT IN SWITZERLAND.

BY FRANK C. PERKINS.

THE Brusio-Campocologna hydro-electric power plant is one of the largest and most up-to-date electric power-generating and transmission developments in the world, a pressure of 50,000 volts being utilized on this Swiss-Italian transmission system.

The water for operating the twelve 3,000-kilowatt turbine-generator sets in this power plant is supplied by Lake Poschiavo in the mountains of Bernina in the southern part of Switzerland, located 3,000 feet above the level of the sea. The rivers Cavagliasco and Poschiavino supply this lake with water, collected from the Palü-Gletscher and the Cambrena-Gletscher. Lake Poschiavo is 35 feet deep at its greatest depth and has an area of 500 acres, being fed by a drainage area of about 50,000 acres.

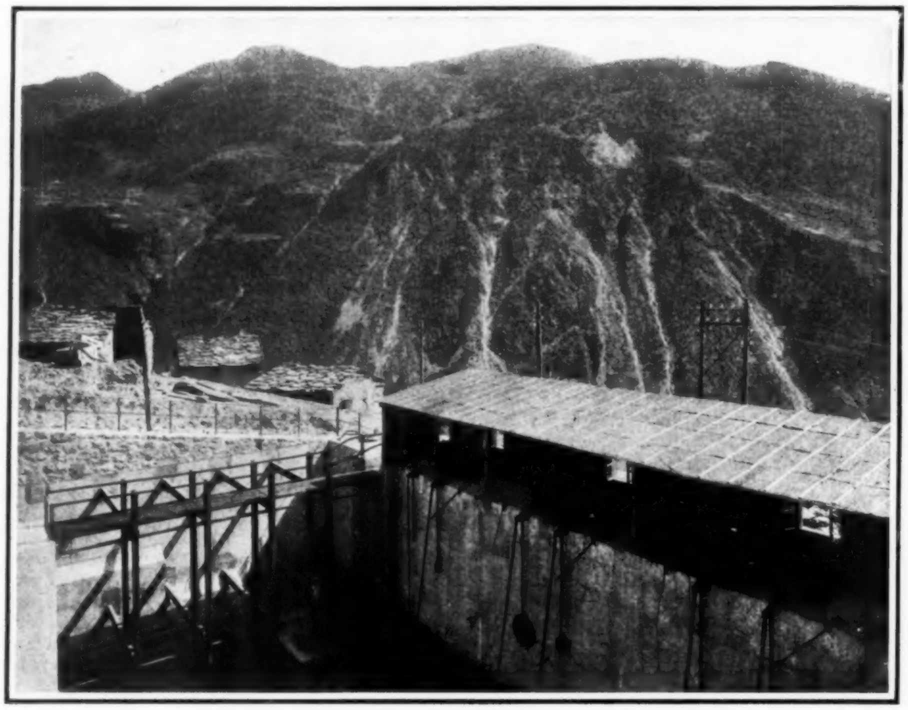
It was necessary to dam the lake at its outlet, so as to raise the water level about 3½ feet above the normal, a siphon being provided so that it might be lowered about 22 feet below the normal level in the winter time, when the water supply is less than during the other seasons. By this hydraulic construction a natural reservoir was provided giving 35,000,000 gallons as a reserve water supply.

Leading from the Lake Poschiavo headrace, a tunnel pierces the mountain to a collecting basin, and the water is carried through penstocks under a head of 1,400 feet to the power plant located at Campocologna. The water is conveyed through the tunnel a distance of 3 miles to Monte Scala, where the collecting basin is located. The headrace tunnel is 22 feet below the normal water level at Lake Poschiavo. A siphon was utilized for connecting the tunnel with the lake instead of directly with the lake bed. A shaft was sunk for this purpose a distance of about 70 feet from the water's edge and carried down about 7 feet below the low-water level, this shaft being nearly 13 feet in diameter, air pressure being utilized in excavating the lower part of this shaft. The tunnel has a diameter of somewhat over 7 feet where it connects with this shaft, leading to the collecting basin. The siphon tube is about 7 feet in diameter and over 250 feet in length. It has a suction leg about 25 feet in length with a butterfly valve and screen, the discharge leg being somewhat longer. There is a double-stage air pump provided for starting the siphon. A centrifugal pump is also installed for cleaning the screen and siphon tube. About two-thirds of the horizontal length of the siphon is located in the lake and under the normal water level.

At the outlet of the lake there are half a dozen sluice gates. A pipe is provided nearly 3 1/3 feet in diameter, equipped with a gate and leading from the basin to the headrace tunnel several hundred feet below. This was utilized as a secondary water supply to start the plant at an early date.

The headrace tunnel is 16,000 feet long. A part of it lies 100 feet deep, although the greater portion is 400 feet underground. Where cut through the rock, the tunnel was lined with concrete only to a point above the water line; but where the tunnel passed through moraine, a distance of about 60,000 feet of loose earth, it was constructed of concrete and reinforced concrete.

A temporary power plant was installed for lighting service and for supplying compressed air during the construction of the tunnel. This power plant took advantage of the fall of the River Sajento, a headrace being constructed of wood, giving a head of 1,400 feet. A 500-horse-power turbine was installed of the Escher-Wyss type, operating at a speed of 600 revolutions per minute and directly coupled to a three-phase alternator supplying a current having a frequency of 500 periods per second and a pressure of 4,000 volts. The same turbine was used for operating a compresssor. This compressor supplied compressed air at a pressure of six atmospheres through two main pipe lines for operating the pneumatic drills, which were mounted on trucks and were moved along on tracks in the tunnel for cutting through the rock.



INTERIOR OF WATER GATE.

The bottom of the tunnel is flat, and the section is egg shaped. The average velocity of the water in the tunnel is 5 feet per second.

It may be stated that the collecting basin is located 1,300 feet above the valley, and is provided with a half dozen penstocks arranged in pairs, each of the latter being provided with screens and located in separate chambers. It is stated that, on account of the sudden rise and fall of the water, the usual practice of using cut-off gates for the penstocks was not followed. Instead an automatic float was devised for signaling the operator and for operating a swing gate, by releasing a pawl and magnetic clutch. The gate house through which the six penstocks pass is located about 100 feet from the collecting basin.

It will be noted from the accompanying illustrations that the penstocks run down the mountain slope at different angles with about a dozen anchorages, solid concrete blocks being used for this purpose. The penstocks rest on concrete piers located between these anchorages. Slip expansion joints are provided where required. A vent pipe is installed for each penstock at the head gates. For draining the water into the tailrace at the lower ends of the penstocks, special drainage gates are installed. A cross pipe having two outlets is used for interconnecting the six penstocks. One of the outlets is provided with a safety device, a "bursting plate" giving way and relieving the penstocks in case of excessive pressure, the cross pipe also maintaining a uniform circulation, its other outlet leading to the exciters.

There are five penstocks in place, corresponding with the main turbine sets, two different types of wheels being installed in the power house. The Campocologna power house is located on the River Poschiavino and has a main generating room about 350 feet long and nearly 60 feet wide, with a single-story switch annex somewhat shorter and about 11 feet wide. There are twelve turbines and main generator units, each having a capacity of from 3,000 to 3,500 K. V. A and four 250-horse-power exciter units. There are two main Pelton wheels of the Ecsher-Wyss type, and four main Girard turbines constructed by A. G. Piccard, Pictet & Cie, of Geneva, Switzerland, all of these turbines oper-

INTERIOR OF THE BRUSIO HYDRO-ELECTRIC POWER PLANT.

A SWISS-ITALIAN 50,000-VOLT POWER-TRANSMISSION SYSTEM.

ating at a speed of 375 revolutions per minute and developing 3,000 kilowatts, or about 4,000 horse-power each.

The exciter turbine equipment consists of two Girard wheels of Piccard-Pictet construction and two Pelton wheels built by Escher-Wyss & Company, of Zurich, Switzerland, all of these exciter turbines operating at 430 revolutions per minute and developing 150 kilowatts each. The turbines and generators are direct connected by insulating flexible couplings of the Zodel-Voith system. There is an electrically-operated traveling crane of 25 tons capacity in service in this Brusio hydro-electric plant, operating a distance of 328 feet along the power house for use in the erection and repair of the electrical generators, turbines, and other equipment.

The main generators are of the three-phase type constructed by the Alioth Electric Company of Basel, Switzerland, each machine having a capacity of 3,000 to 3,500 K. V. A., generating a current having a frequency of 50 periods per second and a pressure of 7,000 volts. These alternators are of the revolving field type with 16 poles, and are capable of carrying an overload of 25 per cent.

The four exciter turbines of 250 horse-power each are each directly coupled to a six-pole shunt-wound Alioth dynamo of 115 volts pressure. These machines operate at a speed of 430 revolutions per minute, and develop 150 kilowatts with an overload capacity of 25 per cent. Each exciter generator is capable of supplying sufficient current for exciting the fields of four of the main generators.

The electric current generated in the Brusio hydroelectric plant is conducted through a tunnel 1,600 feet long and somewhat less than 10 feet square in section to the Piattamala sub-station. The conductors passing through this tunnel leave the power house from the basement of the switch room, and cross the Poschiavino River through a covered bridge.

A peculiar regulation of the customs of the two countries of Italy and Switzerland requires that the tunnel cannot be entered from the power-house end. An iron door separates the Swiss and the Italian sections at the tunnel boundary line, the customs regulations however allowing an entrance through a door visible from the street.

The Piattamala step-up sub-station raises the pressure of the three-phase current generated at 7,000 volts in the Brusio-Campocologna plant to 50,000 volts for use on the transmission line.

In this sub-station there are 24 single-phase transformers, each having a capacity of 1,250 K. V. A., to be installed, 13 transformers having been first placed in position with a normal capacity of 16,250 K. V. A., or over 20,000 horse-power.

The transformer house is 175 feet long and is constructed in the form of a T, the width being 7 feet and the height 25 feet, the cross arm of this sub-station being 84 feet long and 43 feet high. The transformers are of the Alioth water-cooled oil type and have an efficiency of 97.5 per cent at full load and 96.5 per cent at half load. Each transformer is provided with a three-pole oil switch of 7,000 volts on the low-tension side and three oil switches of 50,000 volts capacity, one on each phase, on the high-tension side. These switches are remote-controlled and interconnected, operating either automatically or by hand as desired.

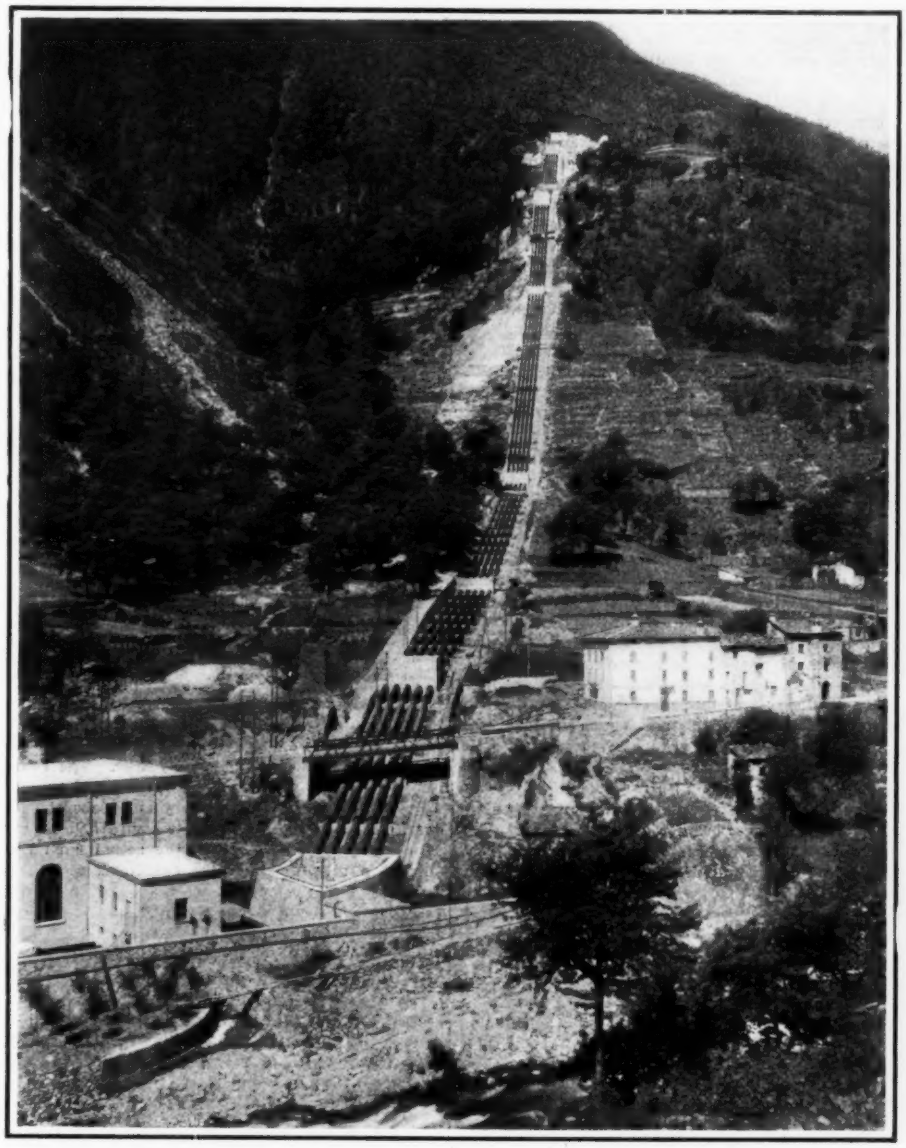
From this step-up transformer station the current is conducted a distance of 90 miles over a transmission line of 50,000 volts pressure through nearly one hundred towns and across three provinces.

The transmission line runs westward to Colico through the Adda Valley. It then passes along the shore of Lake Como to Bellano and over the plateau Valsasina. The highest point on the line is 2,000 feet above the sea level at Palasco.

The transmission line is carried through the Lecco Mountains and across the Adda Valley with a span 700 feet long. This is the lowest point on the transmission line, about 600 feet above the sea level.

The transmission line from the step-up transformer station is nearly straight for a distance of about 85 miles to the first step-down sub-station at Lomazzo, another sub-station being located at Castellanza, about 8 miles farther on.

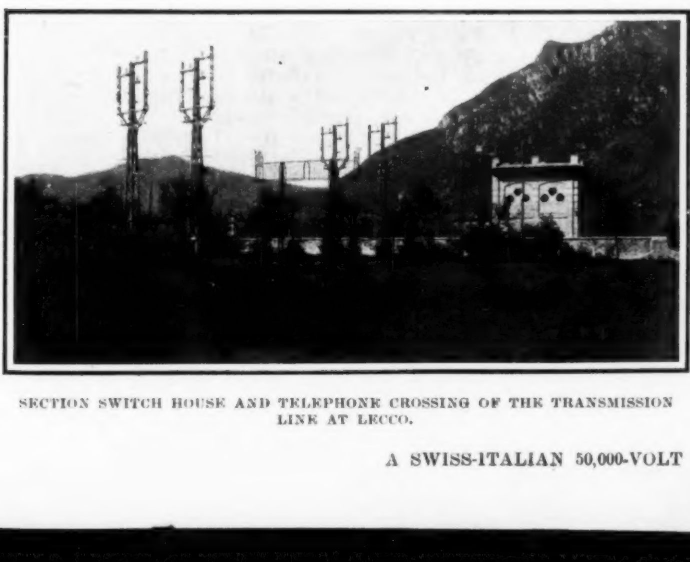
The power is generated, transmitted, and distributed by the Societa Lombarda. The longest span on the transmission line is across the Gravina Valley at Colico and measures 1,300 feet in length; and although in nearly a hundred cases the spans exceed 370 feet in length, that is the average span, or about 400 feet. There are two parallel rows of towers of latticed girder construction for supporting the transmission line, these towers being imbedded in concrete and placed about 15 feet apart. There are half a dozen brackets on each tower for supporting four three-phase circuits, half of these brackets being now in use, the remaining three being reserved for future extension. The transmission cables are mounted on porcelain insulators supported on pins fastened to oak blocks fixed to the steel brackets on the towers. These towers are designed to stand a wind pressure of 60 miles per hour. The transmission line is divided into six sections varying from 8 to 35 miles in length.



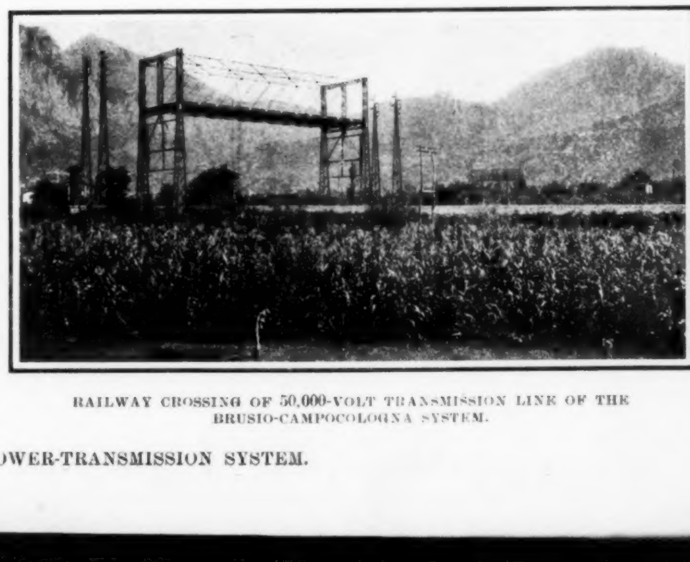
PENSTOCKS, CONCRETE SUPPORTING PIERS, AND CONCRETE ANCHORAGES.

TESTS ON REINFORCED CONCRETE BEAMS.

AN important paper on this subject was read before the Canadian Society of Civil Engineers. In the main, the author, Mr. E. Brown, presents a record of more exact and detailed measurements of the actual deformation of concrete beams than has hitherto been made, and embodies a plea for a simpler treatment of the question from its theoretical side than has been usual in much recent work on the subject. All existing theories of the strength of reinforced concrete beams are based on the assumption that the deformation of the various layers of the beams follows the same law as that for an ideal homogeneous substance, i. e., that



SECTION SWITCH HOUSE AND TELEPHONE CROSSING OF THE TRANSMISSION LINE AT LECCO.

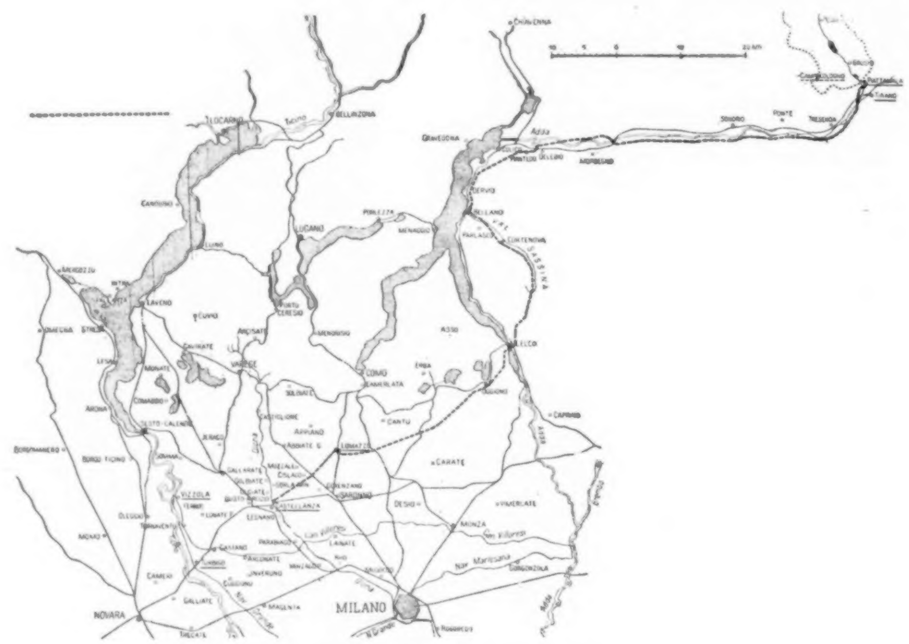


RAILWAY CROSSING OF 50,000-VOLT TRANSMISSION LINE OF THE BRUSIO-CAMPOCOLOGNA SYSTEM.

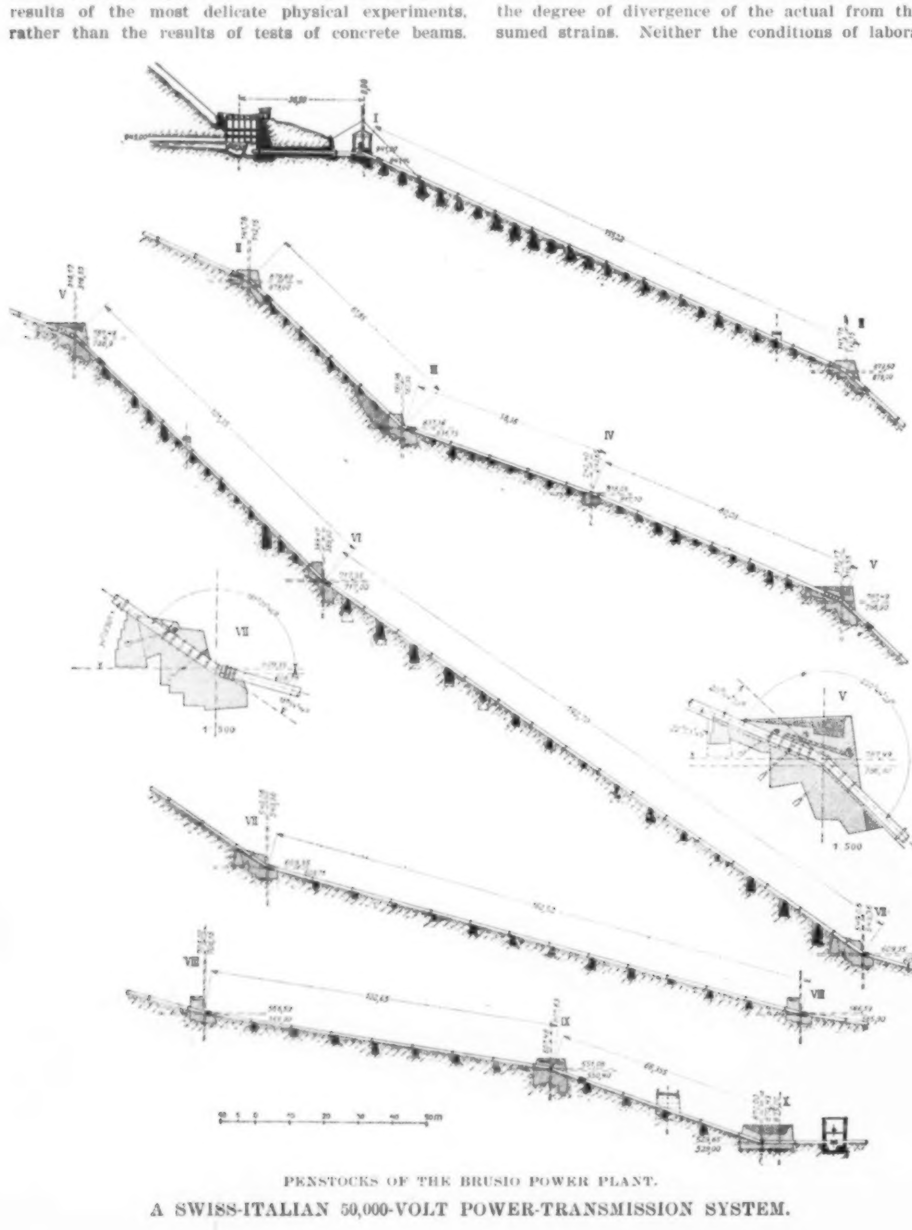
A SWISS-ITALIAN 50,000-VOLT POWER-TRANSMISSION SYSTEM.

it is proportional to the distance of the layers from the neutral surface. This law is not *absolutely* true for all steel sections. Exact extensometer measurements will indicate slight discrepancies, not of such a magnitude, however, as to mar the practical accuracy of calculations based on the law of linear strains. Concrete does not possess the same degree of homogeneity as steel, and the localization of a large proportion of the internal tensile stress of the beam in the isolated steel rods must set up in the surrounding concrete conditions of stress not absolutely determinate, and in any case differing from those of an ideal beam in which the steel is supposed to be distributed through the entire width of beam. The extensometer measurements made at five layers of the beams tested show that the actual deformation curve may be (*a*) linear, as assumed in the theory; (*b*) concave toward the compression side; (*c*) concave toward the tension side. In no case can the exact form of the curves be known without actual testing. The concavity, when it appears, is quite distinct. The fundamental assumption of linear deformation is, therefore, inexact in many cases. Reference to the curves accompanying the paper shows that if a straight line be drawn joining the points representing the compression at the outer layer of the concrete and the extension at the reinforcement line, it would locate a layer of zero strain, i. e., the neutral surface, in a position differing materially from that obtained by considering the five actual observations. This difference is a very appreciable fraction of the effective depth of the beam in many cases, and is quite comparable with, even if it does not exceed, the difference in the position of the neutral surface which results from comparative calculations based (*a*) on a constant modulus of elasticity of concrete; (*b*) on a variable modulus of elasticity of concrete. The justification of the introduction of the latter theory can therefore scarcely be tested by comparing its results with an experimental location of the neutral surface given by arbitrarily drawing a straight line between two points representing extreme tension and compression deformations.

The apparent exactness and the complexity of many recent formulæ suggest that they express closely the results of the most delicate physical experiments, rather than the results of tests of concrete beams. In the author's opinion these formulæ have been built up on an inadequate experimental basis, and it is his belief that a study of the results of careful measurements of the actual strains throughout a beam section, such as have been described, should form the starting point for our theoretical considerations. When this is done, the law of linear straining will be found to be only approximately true. The retention of the law of linear strain as the basis of any theory should then render unnecessary any elaborate modifications which produce changes comparable only with the degree of divergence of the actual from the assumed strains. Neither the conditions of laboratory test nor of practice can be specified to a degree of accuracy even approximating to that of some of the formulæ used, and the author trusts that a realization of this fact may result in the general adoption of simpler formulæ, more appropriate to the actual conditions.



50,000-VOLT BRUSIO POWER-TRANSMISSION LINES.



PENSTOCKS OF THE BRUSIO POWER PLANT.

A SWISS-ITALIAN 50,000-VOLT POWER-TRANSMISSION SYSTEM.

REMOTE-CONTROL BY ELECTRIC WAVES.

AN interesting apparatus recently constructed by two engineers of Nuremberg, Germany, Messrs. Wirth and Beck, allows, through the medium of electric waves, any levers to be thrown forward or backward, upward or downward, steering wheels or cocks to be turned in a right-hand or left-hand direction and electrical apparatus to be thrown in or out of circuit. In fact, it provides a means of controlling the most varied machines from a distance without there being any material connection between them and the operator. The idea of using Hertzian waves is, of course, not new.

At demonstrations recently made of this apparatus before the Nuremberg Society of Natural History and other societies the experimental table contained a plant for receiving electric waves similar to those used for wireless telegraphy, connected to the radio-telegraphic controller and the accessory apparatus actuated by the latter.

In another room was installed a radio-telegraphic sending apparatus susceptible of being tuned up to the receiver, and actuated by electromagnetic waves from the apparatus installed on the experimental table. No connecting wires were provided between the sending and receiving apparatus.

Whenever a lever connected with the sending apparatus was adjusted to various positions the apparatus corresponding to these was actuated. A number of electric lamps were thus lighted in any order desired, or in groups, and a small steam engine was started, reversed or stopped, while electric bells and motors were actuated, powder mines exploded and a revolver fired rapidly.

While torpedoes can be employed so far only over small distances, it is claimed that it will now be feasible to provide them with a far greater driving power, thus directing them toward their goal with safety and from many miles distance.

Land and sea mines have frequently been exploded by electricity transmitted by extensive cables between the operator and each of the mines. The same operation can now be effected through electric waves, that is, by wireless means, provision being made so that only the mine in question is exploded. This firing of mines through electric waves is likely to be adopted advantageously by several branches of industrial activity.—The London Times Engineering Supplement.

The presence of albuminoids in a liquid may be detected by adding a drop of commercial formalin solution (40 per cent) and a drop of a very dilute suspected liquid in a test tube, and introducing beneath it, through a long-stemmed funnel, an equal quantity of sulphuric acid. If much albumen is present a blue-violet ring will be formed at the surface of contact of the two liquids. If very little albumen is present no ring is formed, but if the tube is shaken the resultant mixture will show a reddish-violet coloration. One part of albumen in 50,000 parts of liquid can be detected in this way.

MATTER AND ETHER.

TWO PHYSICAL CONCEPTIONS SIMPLY EXPLAINED.

BY L. DE LAUNAY.

MATTER is familiar to us, and its apparent properties seem natural because we have known them from infancy, but physical science requires another medium, ether, which we have to imagine. We cannot assert that ether has an objective existence, but everything takes place as if it had; and all the complex properties, which we are forced to attribute to it, produce logical consequences which are susceptible of experimental verification. These things suffice to justify a conception of which the first suggestion was made by Descartes.

We have every evidence that space is not filled with matter, properly so called. Not only in the interstellar spaces, but also in the interior of every substance we are led, by various phenomena, to imagine something different from vacuum existing between the material particles. Our minds refuse to admit action at a distance across an absolute vacuum, the physical definition of which, moreover, is as difficult to form as the psychological definition of space or distance. Yet light is propagated through what we call vacuum; and when light travels through a material body it does so almost independently of the material molecules, which serve merely to retard it. Hence its vibrations must be transmitted by the elasticity of the ether. The notion of the ether was first conceived to account for luminous phenomena, and it was afterward adapted to electrical phenomena. Soon, also, men were led to think that material particles are never actually in contact with each other, but are always separated by ether, which is the seat of the observed torsions, expansions, transparency, conductivity, etc.

What is ether? We shall see that it may be regarded either as the initial or as the ultimate form of matter, but this is only a hypothesis. We must first point out the essential differences between ether and matter. Matter is essentially discontinuous and composed of particles capable of relative motion. In mechanics and physics matter is supposed to be divided into molecules, which the chemist in turn finds necessary to resolve into atoms. These material particles, which can move with great velocity and upon whose movements the kinetic theory of Bernouilli is based, cannot support tension and can act on each other only by means of the intervening ether. Let us endeavor to form an idea of their dimensions. Various experiences prove that in a sheet of matter of a less thickness than thirty millionths of a millimeter, or about one millionth of an inch, the properties of matter depend upon its thickness, doubtless because only a few molecules are left. Hence we are led to suppose that the molecules themselves are of this order of magnitude. According to the kinetic theory of gases a cubic inch of gas may contain more than three million million molecules, each of which undergoes 250,000 collisions in traveling one inch; but in a good modern vacuum the few remaining molecules have free paths of several centimeters. The kinetic energy of these molecules is proportional to their temperature. The mean velocity of a molecule of hydrogen at 32 deg. F. and at the atmospheric pressure is 6,070 feet per second.

Ether is altogether different from matter. Approximately it may be regarded as whole, a homogeneous "plenum," everywhere alike. It is sometimes regarded as continuous, but it is so only by contrast with the discontinuity of matter. For ether itself may be divided into electrons and ions, the electron forming, according to present views, the necessary bond of union of transition between matter and ether, the mutual actions of which imply a community of substance. Ether, unlike matter, does not move, except in a special kind of vortex motion. It is eminently well fitted to manifest tensions and other stresses, vibrations, undulations, so that it may be defined simply as that which undulates; or, again, as a medium in which a periodic phenomenon is propagated without movement. This ether, to the idea of which we have to accustom ourselves gradually, may be regarded as a fluid of negligible mass, since it does not sensibly retard the movements of the heavenly bodies, and yet of enormous elasticity, since it transmits light with a speed of 300,000 kilometers (186,000 miles) per second. It is as impossible to cut it, to displace it mechanically, as it is to change the internal structure of the atoms of matter. It should be added, however, that ether is neither invisible nor destitute of density. It is in reality the only thing that we see, since light is simply a vibration of ether, and is almost independent of matter. The calculations of Fresnel, confirmed by the classical experiments of Fizeau, have proved that light is propagated through the ether alone, the transparent material medium exerting, however, a slight effect upon the velocity of light, by means of its own velocity. Ether is denser than any known material, and it is more rigid than steel.

What occurs when we see, in the spectroscope, a line due to hydrogen in the spectrum of a distant star?

FIG. 1.—NORMAL FORM OF CORPUSCLE.
Front, intermediate and profile views.

We must imagine that on the star the ether contained in an atom of hydrogen has undergone a luminous excitation, which is now explained by the production of electrified particles or electrons. This electrification produces a tension in the ether, in the form of alternating currents similar to those of Hertz's experiments, which change their direction millions of millions of times in a second. The enormous induction due to this rapid alternation produces similar alternating currents in neighboring parts of the insulating elastic ether. In this way the wave of light, endowed with the properties characteristic of hydrogen, is propagated

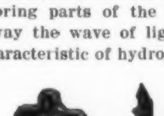


FIG. 2.—STELLATE FORM OF CORPUSCLE.
Front and profile.

in all directions with the velocity of 186,000 miles per second, through the immense ocean of ether, and finally strikes our retina and produces the sensation that we call sight.

We have supposed hitherto for simplicity an independence between matter and ether, which does not really exist. In fact, matter and ether continually act upon each other, although these reactions are small in comparison with those of either medium on itself. An evidence of this mutual action is given when a ray of light passing through a transparent moving body has its velocity modified by the velocity of the body. Another evidence is the fact that the velocity of light is less *in vacuo* than in any material substance. The phenomena of emission and absorption show matter

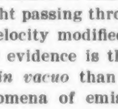


FIG. 3.—MULBERRY FORM OF CORPUSCLE.

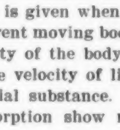


FIG. 4.—THORN-APPLE FORM OF CORPUSCLE.

producing and absorbing ether waves. But a much simpler and more familiar daily experience furnishes similar evidence. We seize the end of a long rod and the whole rod follows our effort. The separate molecules which compose it act upon each other and they can do so only through the intermediation of the ether. We apparently coil a steel spring, but what we really coil is the ether interposed among the atoms, which are indeformable and susceptible only of displacement. In fact, as soon as we regard any of these phenomena closely we see that most of the properties commonly attributed to matter are really those of the ether in matter; and we are led to suppose the existence of a

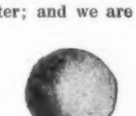


FIG. 5.—SPHERICAL CORPUSCLE.

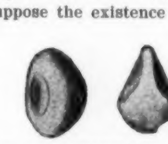


FIG. 6.—SINGLE AND DOUBLE BELL FORM OF CORPUSCLE.

sort of friction between ether and matter which binds them together, the ether around material particles acquiring an increase of tension.

The notion of ether, so indispensable in our theories of light and electricity, does not explain the attraction of gravitation, which is propagated instantaneously, so far as we can determine, and which traverses both matter and ether, without being affected by them. Gravitation undergoes neither reflection nor refraction. No matter how many particles exert this force the effect produced by each particle is the same as if the others did not exist. The supposition has been made that the ether within material bodies becomes rarefied, producing a tendency for the denser ether outside to flow in. Thus we have a pressure produced in ether which is used to explain the phenomena of gravitation. But despite these hypotheses ether does not seem capable of explaining gravitation any better than matter explains light. We are therefore led to ask if, just as ether penetrates into matter and surrounds its molecules, there is not among the discontinuous electrons which compose the ether, an ether of the second degree, still more subtle, more imponderable, denser and more rigid, in which the transmission of vibrations takes place with a velocity which appears to us infinite, and upon which the influence of matter or ether is so small that we can never discover it. This idea, which may appear fantastic, is, on the contrary, in accordance with the logical tendency which leads us to regard the universe as the result of a series of successive integrations, each part reproducing, with the difference of scale which is always striking to our defective organs of perception, the constitution of the whole, so that an atom is a miniature universe.

In conclusion, we must mention a curious hypothesis recently enunciated by Sir Oliver Lodge with the boldness characteristic of English men of science. The human brain, our organ of thought, is composed of matter. Lodge suggests that ether may constitute the instrument of another form of thought which may, to a certain degree, affect our thoughts, just as the ether intervenes in our ordinary sensations. This implies the existence of a mysterious connection between mind and matter.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

EFFECT OF ELECTRICITY ON THE BLOOD.

By LEOPOLD LOEHNER.

SOME light is thrown on the causation of death by lightning strokes and by contact with electrical circuits of high voltage by the result of experiments showing the peculiar changes in the blood which are produced by electric discharges.

Freshly drawn, uncoagulated blood is so opaque that writing cannot be read through a thin film of it inclosed between two plates of glass. If a series of discharges from a Leyden jar is passed through the film of blood by means of tinfoil electrodes, the blood gradually becomes so transparent that the writing beneath it can be read with ease. What is the explanation of this change?

Blood consists of a nearly colorless liquid, the blood plasma or serum, mixed with solid bodies of organized structure, of which the most important are the red corpuscles which contain the red coloring matter of the blood. This pigment, hæmoglobin, is the principal agent of the so-called internal respiration of the body, which it effects by carrying oxygen from the lungs to the various organs and tissues. Under the action of electric discharges the hæmoglobin becomes detached from the blood corpuscles and passes into the serum, which it colors pale red, while the corpuscle, assuming the same pale tint, becomes invisible and transparent. The process is gradual and a certain number of discharges is required for its completion.

Before the blood corpuscle parts with its pigment it undergoes a series of characteristic changes of form. The normal human blood corpuscle is a disk with a thickened rim (Fig. 1). The first discharge causes division of the rim into lobes so that the corpuscle presents a stellate appearance (Fig. 2). Under the influence of the second and succeeding sparks the corpuscle expands, becomes globular and assumes successively the mulberry form with blunt prominences (Fig. 3), and the thorn-apple form with sharp spines (Fig. 4). Finally it becomes a smooth sphere (Fig. 5) and with this change the loss of pigment and opacity begin.

I have discovered that the number of sparks required to produce these changes depends on the relative directions of the electric current and the axis of the corpuscle, and is smallest when these are parallel, probably because the corpuscle in that position offers minimum resistance to the current.

By a modification of the process I produced the bell form (Fig. 6) which was not present in the preparation before the discharges. This form is occasionally found in blood and Weidenreich and others have re-

cently expressed the opinion that it is the normal form of the blood corpuscle and that the common disk-shaped corpuscles have already undergone modification due to cooling on removal from the body. From this point of view it appears very remarkable that electric discharges, which ultimately destroy the corpuscles completely, should begin by restoring them to their original form.

All these experiments led to the same final result, transparency of the blood caused by diffusion of the pigment of the corpuscles through the surrounding plasma. That blood undergoes similar changes inside the human body is proved by the peculiar markings found on the bodies of persons killed by lightning. These branching and tree-like figures are due to discoloration of the skin by pigment released from the blood corpuscles by the electric discharge.—Translated for the SCIENTIFIC AMERICAN from Umschau.

OILS AS DUST PREVENTIVES.*

HOW THEY ARE APPLIED.

BY PREVOST HUBBARD.

OILS as a class are fatty organic substances derived from innumerable sources. They may be most conveniently divided under three heads, as animal, vegetable, and mineral. While oils of the first two classes have been used to some extent as dust preventives, mineral oils are by far the most important, and have been most generally used for this purpose. As animal and vegetable oils, owing to their lack of heavy binding bases, may be ranked as temporary binders, they may be considered most conveniently with the lighter mineral oils and emulsions, which will be taken up later.

The value of an oil as a permanent dust preventive lies in the quality and quantity of high-binding bituminous base retained by the road surface after evaporation of the more volatile constituents. The bases present in petroleums vary from those of almost pure paraffin to almost pure asphalt, many being mixtures of the two. While the paraffin oils are of much more value than the asphalt from a commercial point of view, the opposite is true from the standpoint of their use in dust suppression. An oil wholly paraffin is of value only as a temporary binder or dust layer, while an asphalt oil, owing to the character of the base contained, ranks with coal tar as a permanent binder. Like coal tar, petroleum is a mixture of a great number of organic bodies known as hydrocarbons, together with small quantities of sulphureted, nitrogenized, and oxygenated compounds. The approximate composition of crude petroleum is ordinarily determined by distillation, but a knowledge of the residuums left after distillation is of far more value from the standpoint of dust suppression. Considerable attention has been paid to these residuums, as well as to the characteristics of oils from the various fields, by Richardson, who in a recent paper† has published the results obtained by himself and other investigators. It is this classification that will be followed in considering the value of different oils as dust preventives.

There are seven distinct oil fields in the United States, which yield oils differing in qualities. The Appalachian, which includes the States of New York, Pennsylvania, West Virginia, southeastern Ohio, and parts of Kentucky and Tennessee, produces oils which are known as eastern oils or paraffin petroleums, and which are therefore of use only as temporary binders in dust suppression. The Ohio-Indiana field produces oils which are much like those of the Appalachian and are also classed as paraffin oils; and the same is true of the Colorado oils. The Wyoming oils vary in character from the lighter to the heavy asphaltic oils which are found principally in California. The oils from the California field, while of the most varied character, consist mainly of more or less dense asphaltic hydrocarbons. None of the components are of the paraffin series, and, as the percentage of asphaltic residue in these oils is usually high and of a good binding character, they may be considered the best for use as permanent binders. Oils from the Texas field are of a mixed character. All of them contain some paraffin as well as a greater or less amount of asphaltic residue. Some have been used successfully as dust preventives, while others are unfit for this purpose. It is needless to say that their value lies in the relative amounts of asphaltic and paraffin base contained. The Kansas oil field, including Oklahoma, produces oils quite similar to those from the Texas field and shows a mixed paraffin and asphaltic base. The Louisiana field also yields oils similar to the Texas. Some of the wells in the Indiana and Kentucky fields have also been successfully used. In general, however, the eastern oils are of the paraffin type and useless as permanent binders; the western oils are of asphaltic character and of great value as permanent binders, while the southern oils are of a mixed character, containing part paraffin and part asphalt bases, their value as dust preventives lying in the relative amount of asphalt base contained.

FIG. 1.—APPLICATION OF OIL TO MACADAM SURFACE.

The residuums resulting from the distillation of the various petroleums have been used to a great extent as fluxes for softening the solid native bitumens used in the paving industries. Their various characteristics and properties have therefore been given considerable study. As the character of the residues present in both crude and refined petroleums is of the greatest importance from the standpoint of dust suppression, the results obtained from a study of these fluxes should be of service in determining the suitability of various oils for this purpose. The character of the residue will naturally vary as the crude petroleums vary, although, as has been shown, the method of preparation may produce considerable effect upon the residue.

The paraffin petroleum residuums are of a soft, greasy character and, as their name implies, contain a large amount of paraffin hydrocarbons and paraffin scale or crude paraffin. A road surface treated with material of this character will be dustless for the time being, but in damp, rainy weather will become covered with a slimy, greasy mud, which is easily washed away and leaves the road in as bad, if not worse, condition than it was before treatment. When the crude or even the residual oil is used solely as a binder, it may therefore be predicted that the outcome will prove a failure.

The base held by the California petroleums is composed of bitumens resembling asphalt. The residuum contains no paraffin and, if cracking has not been employed in its preparation, carries but little free carbon. The specifications for California fluxes call for not over 6 per cent fixed carbon. Both the crude oil and the residuums, if properly prepared, act as excellent binders and have, as a rule, given the best results of any oils which have been used as dust preventives.

The semiasphaltic oils, such as those obtained from Texas, carry an asphaltic base, but also a considerable amount of paraffin hydrocarbons and a little over 1 per cent of paraffin scale. While somewhat inferior to the California products, good results have often been obtained from their use on roads in both the crude and the refined state. Those which contain the greatest amount of heavy binding bitumens and the least amount of paraffin scale are, of course, to be preferred. In order to obtain the best results the residuums, as well as the crude oils of asphaltic or semiasphaltic character, should be comparatively free from water.

Sometimes the residues from the distillation of petroleum while yet hot are subjected to the action of a jet of air, which has a tendency to thicken or harden them. It is doubtful, however, if an oil thus treated will be improved for use as a dust preventive, as the life of the oil is apt to be destroyed and its lasting qualities as a binder lessened.

The use of a paraffin petroleum is just as much to be avoided as a high-temperature tar, and in both cases a good crude product is to be preferred to a badly cracked residuum or one produced from a poor quality of crude material. Considerably more attention has been paid to the actual quality of oils which have been employed as dust preventives than to tars, although the latter have perhaps been more extensively used. A number of specially prepared or refined oil products are now on the market for use on roads, both in the form of residuums and emulsions. The residuum products have been prepared from asphaltic or semiasphaltic oils by methods similar to those described, while the emulsions are usually residuums which have been treated with saponifying agents in order to make them miscible with water.

Comparisons of Crude Oils and Residuums.—Owing to the fact that oils from a number of wells are commonly run through the same pipe lines from the wells to the storage tanks, it is often difficult to obtain two lots of oil having exactly the same properties, even when purchased from the same source. It is very important, therefore, that an examination of each lot of oil be made before attempting to use it for the purpose of dust prevention. Sometimes a partial chemical analysis is necessary, but in the majority of cases a few simple tests will determine its suitability for this purpose. It is also a wise measure to examine residuums even when they are especially advertised as road preparations, for, as has been stated, there is a strong tendency among refiners to crack their oils in order to increase the yield of illuminants, and when this is done the value of the residuum for the purpose of dust prevention will be considerably lessened. If the road engineer understands throughly the properties possessed by the oil which he is handling, he will be able to avoid many dismal failures which might otherwise occur.

Some of the results obtained from an examination of various crude and refined petroleums in the New York Testing Laboratory are given in the following tables in order to show the differences in properties possessed by the different kinds of material. They do not in any sense represent absolute values for the different classes of oils but will serve to give a general idea of the relative characteristics of each.

RESULTS OF TESTS OF PETROLEUM RESIDUUMS.

Kind of Oil.	Specific Gravity.	Flashing Point, Deg. C.	Volatility at 110° C., 7 hours, Per Cent.	Volatility at 160° C., 7 hours, Per Cent.	Volatility at 205° C., 7 hours, Per Cent.	Residue, Per Cent.
Pennsylvania paraffin.	0.891	60	47.3	58.0	68.0	b 32.0
Texas, semiasphaltic..	0.904	43	20.0	27.0	49.0	c 51.0
California, asphaltic..	0.939	26	....	...	d 42.7	e 57.3

a Ordinary temperature. c Quick flow. e Soft maltha; sticky.
b Soft. d Volatility at 200° 7 hours.

It will be noticed from the foregoing results that in the samples examined the specific gravity increases from the paraffin to the asphaltic oil. This is also true of the percentage of residue, while the volatility

* Abstracted from Bulletin 31 of the Office of Public Roads, Department of Agriculture.

† Richardson, Clifford. VI Congresso Internationale di Chimica Applicata, Roma, 1906. Communicazione fetto nella Sezione IV.—A (Industrei dei prodotti organici.)

decreases correspondingly. The residues range in character from soft and probably greasy through an intermediate and but slightly viscous stage to the more or less liquid maltha of good adhesive properties. A rough idea of the character of these bases may be formed by rubbing a little of the residue or even of the crude oil between the finger and thumb. Those of a paraffin nature will feel greasy, while those of an asphaltic character will often exhibit an adhesiveness which is easily distinguishable. The color and odor will also indicate the character of the crude material to those familiar with the different varieties. In comparing the Pennsylvania with the Texas oil, it will be seen that the former carries a higher per cent of light oils than the latter. A comparison of the residuums obtained from refining oils similar to those described in the preceding table is here given:

RESULTS OF TESTS OF PETROLEUM RESIDUUMS.

Kind of Oil.	Specific Gravity.	Flashing Point, Deg. C.	Volatility at 260° C., 7 hours, Per Cent.	Residue, Per Cent.	Solid Paraffin, Per Cent.	Fixed Carbon, Per Cent.
Pennsylvania paraffin..	0.920	186	14.2	a 85.8	11.0	3.0
Texas, semiasphaltic..	0.974	214	6.2	a 93.8	1.7	3.5
California, asphaltic	1.006	191	17.3	a 82.7	0.0	6.0

a Soft.

In comparing these results an increase in specific gravities in the same direction as in the case of the crude petroleums will be noticed. The volatility and percentage of residue, however, are not in the same order. As these are dependent entirely upon the point at which distillation is stopped in the process of refining, such a result is to be expected. The percentage of solid paraffins is found to decrease to zero as the character of the oil becomes asphaltic. Only 11 per cent was found in this particular sample from Pennsylvania, but it is not uncommon for oils of this nature to carry as high as 33 per cent paraffin. The amount of fixed carbon is found to increase with the asphaltic character of the oil, and this fact is quite general, owing to the greater tendency of the asphaltic oils to crack during distillation.

In comparing the crude oils with the residuums it will be seen that the latter, as would naturally be supposed, carry a greater percentage of residue, and, other things being equal, are therefore of more value as permanent binders. A considerable difference is also seen to exist between their flash points, which is the temperature at which their most volatile products flash when brought in contact with a flame. As a general rule it is not difficult to distinguish between a crude and a residual oil, but in cases where any doubt may exist the flash point is a fairly accurate indicator. Thus, in the case of the crude Texas oil and the Pennsylvania residuum, we find that their specific gravities are quite close together, and some doubt might exist as to which was crude and which residual. A determination of their flash points would at once settle this question.

THE APPLICATION OF THE HEAVIER OILS.

Many valuable facts have been learned in regard to the application of oils to road surfaces, although, owing to contradictory results, considerable differences in opinion seem to exist as to the actual and relative values of different kinds of oils under the same conditions and under varying conditions. This is, to a great extent, due to lack of knowledge in regard to the properties of the material used and to the fact that climatic conditions and the character of the road treated have a much more important bearing upon the results than is usually realized.

The subject of oil application, unlike that of tar, has received considerably more study in our country than has been given it by European nations. It is true that various experiments have been carried on in England and France with a number of different oils, but owing to the lack of a proper base in these oils the results have been discouraging. Shale oils and Russian petroleum residuums, known as "masut" or "astaki," have been employed, as well as certain vegetable oils, such as oil of aloes. They have all been found effective as temporary dust preventives, but in rainy weather produce a greasy, disagreeable mud and soon disappear from the road surface. The best results have so far been obtained with heavy oils applied in the form of a spray while hot.

As the application of the temporary binders or lighter oils can best be considered in connection with that of oil emulsions, the application of the heavier oils only will be taken up here. Crude petroleum as well as residuums and specially prepared oils have been used with more or less success on earth and gravel roads, as well as on stone roads, and in this respect have an advantage over tar, which so far has given good results on hard roads only.

Application to Macadam Surfaces.—In applying oil to a macadam surface the same general methods are employed as in the application of tar. Holes and inequalities should be repaired; it has not been found necessary to remove all dust from the road surface so carefully as in the case of tar, but sticks, leaves, and other detritus of an organic nature should be removed.

The crude or refined oil may be applied either cold or hot, according to its viscosity and ability to penetrate the road surface. The application of cold oil is considerably cheaper and is to be preferred on that account. Most crude oils and some of the lighter residuums have been used in this way with good results, but it has been found necessary to heat the heavier products before application.

If much work of this kind is to be carried on in one locality, it is sometimes the custom to erect a stationary heating plant at a convenient railroad siding. A plant of this sort has been described in a previous publication,* and consists of a receiving tank of one tank-car capacity placed preferably so that the oil may be run in by gravity from the car. A heating tank set at an elevation sufficient to allow the hot oil to run into the distributing wagons and fitted with steam coils through which superheated steam may be forced is placed near the receiving tank. The oil may be pumped into this heating tank as required and heated to any desired temperature. Very often the heating is carried on in the tank car, and the hot oil run directly into the distributing wagon. When sufficiently fluid, it can then be applied to the road by means of a large pipe and broomed into the surface in the same manner as tar. Patented distributing devices have been employed which can be attached to almost any form of tank wagon and which, if the oil is fluid enough, will do away with the necessity of brooming. An oil applied by this means will, however, have to be heated to a higher temperature than in the former case, as the openings in the distributer are of small dimensions and will not allow the oil to pass freely if it is in a very viscous state.

As in the case of tar, the main object is to obtain an even coating, which shall be well absorbed by the road surface. The application of a large excess of oil should be avoided, as it is sure to make the surface sticky and disagreeable. A covering of sharp sand or one-half inch stone screenings should be applied after the oil has been allowed to penetrate as much as possible, in order to take up all excess, and the surface thus formed should be rolled until well compacted, additional sand or screenings being thrown on wherever the oil shows a tendency to force its way to the surface and produce a sticky condition. Sometimes two or three courses of oil and screenings are applied. It is usually considered better to allow the freshly oiled road to dry out to some extent before applying the top dressing, but in cases where it is impossible to keep traffic away the same methods may be employed as in the case of tar, i. e., either one-half the width of the road may be treated at one time or the sand or screenings may be applied at once. If the oil is well absorbed it is not always necessary to employ the roller, as ordinary traffic will consolidate the surface in the course of time.

Application During Construction of Macadam Road.—The application of oil during process of construction has been carried on with the greatest success in California, where the heaviest asphaltic oils are found. The residuums obtained from the partial distillation of these oils have so far given the best results when properly applied. The treatment is essentially the same as with tar, the object being to build a road containing a low percentage of voids, so that the oil will act as a binder only and the strain of traffic be borne by the road stone. Considerable attention should be paid to proper drainage of the road, as it is essential that the foundation be perfectly dry. The macadam is built in the usual manner and each course thoroughly rolled until the whole road is well consolidated. If water is used during the process of construction sufficient time should be given for the road to become perfectly dry before applying the oil. The hot oil is applied by means of a tank wagon fitted with a distributing device which insures an even distribution. Any excess of oil is taken up by the application of a sufficient covering of sand and screenings, and the road is then opened to traffic.

A road constructed in this manner will usually require from $\frac{3}{4}$ to $1\frac{1}{2}$ gallons of oil per square yard, depending upon the quality of oil employed and kind of road surface treated.

As in the case of tar work, the softer and more porous rocks, such as limestone, permit of a better penetration than the harder rocks, such as trap and granite, but good results have been obtained by the use of both kinds. Oils as a class seem to penetrate better than tars, as they do not harden as quickly upon exposure to the air. In order to keep the road in proper condition, repairs should be made as often as necessary, and in the same manner as in the case of tars. By this means rapid disintegration will be prevented, which would otherwise occur if water were allowed to accumulate in the worn places.

Application to Gravel Roads.—A gravel road is oiled in much the same way whether it is an old road or one under construction, as only the upper course is treated in either case. It is especially important in a road of this kind that the drainage be good, and this matter should be attended to first of all. Any holes or pockets which may exist should be cleared out, if much fine material is present, and filled with clean, fresh gravel, so that the surface of the road will be uniform when the patches have been sprinkled and rolled. If the lateral drainage is bad, the entire surface should be loosened and brought to proper grade and crown by the addition of new material before the oil is applied. In this case more oil will be required to effect a good bond than if the old compacted surface was treated, but the results will be of a more lasting character. The oil may be applied either cold or hot, according to its viscosity, by any of the methods already described. It should contain a high percentage of good asphaltic base, or otherwise the material near the surface will become loose, owing to the lubricating qualities of the oil. The use of too much oil should be especially avoided, and all excess should be taken up by the addition of fresh gravel. Where the surface treated is loose and contains a considerable amount of clay, the oil may be worked into the upper course by raking, which insures an equal distribution. After application of the oil, the road should be rolled until properly compacted, and as this is apt to bring some of the oil to the surface, fresh material should be added where necessary. If the freshly oiled road is not well rolled, the action of traffic will bring the oil upward; a soft spongy surface condition will be produced; loose, oily particles will be thrown out by rapidly moving vehicles; and the oil will be tracked by pedestrians.

Oil is applied to a gravel road during construction in a manner quite similar to that already described, but certain points in regard to the method of construction should be noted. These facts are well presented by the commissioner of the department of highways of California* in a report which contains speci-

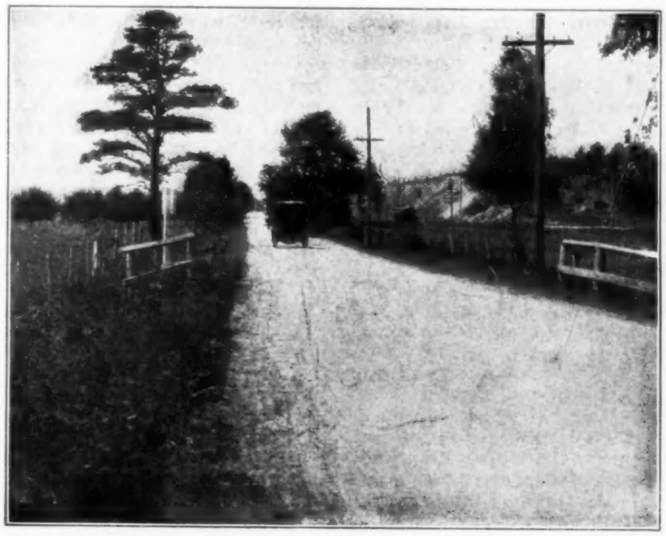


FIG. 2.—FAST-MOVING AUTOMOBILE ON OILED ROAD RAISING NO DUST.

* "Use of Mineral Oil in Road Improvement," Year Book Dept. Agric., 1902, page 446.

* Biennial Report, 1906.

fications used in certain parts of that State for the construction of oiled graveled streets. As California has been most successful in this kind of work, a study of the methods used there should be of great value to experimenters in other localities. Certain portions of these specifications in condensed form are given below for the purpose of emphasizing the most essential points.

Before placing the gravel the subsurface must be brought to grade and rolled. Upon this subsurface two layers of good gravel should be applied, the bottom layer having a thickness of 5 inches and the top a thickness of 3 inches after being rolled. The first layer should contain no stones larger than 2½ inches in greatest diameter. The gravel must be uniformly spread on the roadway and well moistened, rammed 1 foot from the gutter or curb, and the remaining portion rolled with a roller of the type before specified. All depressions must be promptly filled, moistened, and again rolled, the rolling being continued until the surface will not yield under the roller. On this surface the top layer of gravel, free from all stones larger than 1 inch in greatest diameter, should be applied and compacted in the same manner as the first layer. Oil should then be evenly distributed over the entire surface at the rate of one-half gallon per square yard, and covered with clean, sharp sand until no oil can be seen. After the lapse of not less than twelve hours, another application of oil should be made and sand distributed in the same manner and the whole surface rolled until unyielding to the roller, as before described.

These specifications require that the oil be crude and that it be applied at a temperature not less than 150 deg. F. nor above 190 deg. F. Certain methods of testing the properties of the oil are included in the specifications. In regard to measuring the petroleum, it may be said that the volume at 60 deg. F. is taken as normal, and a deduction of 0.1 per cent is made for every 10 deg. increase over this normal temperature as a correction for expansion by heat.

Use of Oil on Earth Roads.—The use of oil on earth roads was first tried in this country in California. Crude petroleum was sprinkled upon the road for the purpose of laying the dust only. It proved to be a very effective dust layer, and in some cases improved the condition of the road surface to such an extent that popular attention was aroused, and as a result many experiments were made with a view not only to laying the dust, but to hardening the surface. Since then oil has been used with varying success and failure, and much valuable information has been derived from the experiments. California is particularly favored for work of this nature, owing to its climate and the character of its roads, as well as to the excellent road-building properties of its oils. Although it is impossible to duplicate these conditions in other localities, the lessons learned from the numerous experiments conducted in this State are of great interest as offering suggestions for work of a similar nature in other places.

It has been found that the character of the soil plays a most important part in the results obtained, and different kinds of soils have to be treated in different ways. Alkali soils disintegrate the oil and destroy its binding qualities. A sandy loam is the most suitable for treatment, and almost invariably gives good results when treated in the proper manner with an oil of good binding quality. From a physical standpoint clay is probably the worst of all, as it does not absorb the oil well and exhibits a tendency to ball up and give trouble. Sand should therefore be added to the clayey surface until this difficulty is overcome. As in the case of gravel roads, special attention should be paid to drainage, and the roadbed should be dry when the oil is applied. If the foundation is water-soaked, it soon loses its ability to support the surface properly, which will then break through in weak spots.

The use of too much oil should be avoided, as it will produce a spongy surface condition and increase the draft of vehicles to a considerable extent. It is most important to keep a road thus treated in good repair. Whenever a rut or hole develops it should be cut out, oil should be poured in, and it should be filled up with good earth or sand. The loose material should then be thoroughly tamped until even with the surrounding surface.

Besides the method of oiling earth roads already described, another has recently been employed with considerable success in California. This method differs from the other in two essential particulars. The first of these is that water is applied during the process of oiling, and the second that consolidation is produced by a special tamping device. The method has given satisfactory results with sand and clay roads, as well as with loam and gravel, and is conducted as follows:

The road is first plowed up to the depth of 6 inches and properly crowned. All clods and lumps are then thoroughly broken up by means of a harrow, and the roadway is well sprinkled with water. A specially constructed rolling tamper is then used by which the lower portion of the loose earth is compacted to a depth of about 2 inches, except in cases where the subgrade is unusually firm.

After the lower portion is made firm by this means a heavy asphaltic oil is applied at the rate of about 1½ gallons per square yard, and a cultivator is passed over the road until the oil and earth are thoroughly mixed. The tamper is then used again, and the road is further compacted until only 1½ inches of loose material remain on top. This is lightly harrowed and sufficient water is added to moisten it. Oil is again applied, and the surface is rolled with the tamper until firm, and finally it is ironed down with an ordinary roller, additional applications of earth being made wherever necessary to take up any excess of oil.

A road constructed in this manner will require from 2½ to 3 gallons of oil per square yard. It is hard and dustless and resembles asphalt.

The California oils are best adapted for this method of road building, but the cost of transportation to the Eastern States at the present time raises the price to a prohibitive figure. The Texas and some of the Kentucky oils are the best available for these localities, and range in price from about 4 to 8 cents per gallon, according to the locality. The residuums and special preparations vary from 2 to 12 cents per gallon. It is impossible to estimate cost of application except for individual cases; but, in comparison with cost of tar application, it would seem that where both products can be obtained close at hand oil is usually somewhat cheaper.

The natural enemies of the tarred road are also enemies of the oiled road. All kinds of properly oiled roads are dustless, noiseless, waterproof, and resilient, and offer but little resistance to traffic. The crude oils have a rather unpleasant odor, which soon passes away. Both the crude and residual oils exhibit a somewhat weak germicidal action. If an excess of oil is present upon the road surface, an oiled mud is formed in wet weather which is damaging to clothes and the paint on vehicles, but this condition is not met with if the proper amount of the right kind of oil is employed.

HARDENING HYDRAULIC CEMENTS.*

A DESCRIPTION OF A NEW PROCESS.

BY DR. W. MICHAELIS, SR.

THE following table shows the composition of some fused calcium-alumina-silicates:

	A	*B*	*C*	*D*	*E*	*F*
SiO_2	= 35,13	31,05	35,77	34,52	31,16	30,58
Al_2O_3	= 11,97	10,58	12,97	14,07	12,72	14,31
CaO	= 45,92	52,10	44,54	43,21	48,65	43,14
MgO	= 1,38	1,30	1,72	1,67	1,51	3,16
FeO, MnO	= 1,00	0,90	1,00	1,53	1,44	1,33
CaS	= 4,60	4,07	4,00	5,00	4,52	7,48
	100,00	100,00	100,00	100,00	100,00	100,00

The ratios of their molecular weights are:

	A	B	C	D	E	F
SiO_2	= 5	5	90 Melilite	75 Mel.	D +	5,1
Al_2O_3	= 1	1	5 Gehlenite	19 Gel.	10,6 CaO	1,4
$CaO(MgO)$	= 7	9				8,7

(If, in the case of *F*, all alumina is assumed to have contributed to forming gehlenite, that is to say, $2\ SiO_2$, Al_2O_3, $3\ CaO$, there remain 2, 3 mol. SiO_2 and 4, 5 mol. of CaO, hence almost exactly calcium ortho-silicate. This silicate, therefore, will disintegrate on cooling in the same manner as do *B* and *E*.)

You recognize these as the compositions of such blast furnace slags as assume hydraulic properties upon combination with calcium hydrate, if they have previously been granulated, that is to say if they have been transformed into the glass-like state. They thus become slag-puzzuolana cements.

If a similar slag, for instance *B*, which fuses at 1,500 deg. C. is cooled slowly, various minerals can crystallize from it. On cooling slowly down to 1,300 deg. C. augite is formed and hexagonal calcium metasilicate, the unstable modification of wollastonite; on cooling rapidly to 1,300 deg. C. and then slowly to 1,000 deg. C. crystal mixtures are formed which the original investigator of the fused silicate solutions, Prof. Vogt, of Christiania, has termed the melilite group. He describes the melilite group as an isomorphous group occurring in high-limed aluminous silicate fusions forming mixtures of crystals of the same appearance and same specific gravity, splitting in a similar way and crystallizing in the tetragonal system. At the one end of this group we find the acidic akermanite and at the other the basic gehlenite.

A is such an ideal melilite consisting of:

1 Mol. Akermanite = $3\ SiO_2$, $4\ CaO$ and
1 Mol. Gehlenite = $2\ SiO_2$, Al_2O_3, $3\ CaO$

Melilite, therefore, is:

$$Si_5Al_2Ca_7O_{20} = 5\ SiO_2,\ Al_2O_3,\ 7\ CaO$$

But if a slag as *B* is cooled rapidly to a temperature below 1,000 deg. C. and then for a long time kept at a temperature between 900 deg. C. and 700 deg. C., it completely changes its structure and assumes a physical appearance entirely different from a slag which has been cooled quickly and completely; it becomes spongy and foamy and gives off sulphurous acid. This change is caused in the first place by the decomposition of the calcium sulphide which was dissolved in the silicate and in the second place by the dissociation of gehlenite; free calcium oxide separates, the gehlenite decomposes and forms anorthite and calcium oxide: $2\ SiO_2$, Al_2O_3, $3\ CaO$ gives off $2\ CaO$ and forms $2\ SiO_2$, Al_2O_3, CaO. I shall come back to this later.

For the formation of the above mentioned crystals it is of advantage or very likely even absolutely necessary that a certain percentage of magnesia be present. Vogt himself is of the opinion that about one-fifth of the calcium oxide must be replaced by magnesia, if akermanite is to be formed. Messrs. Day and Shepherd could not obtain akermanite from silica and calcium oxide. I have likewise tried in vain up to this time to obtain this mineral with certainty.

When I tried to fuse at 1,600 deg. C. a mixture of $9\ (SiO_2,\ 4\ CaO) + (3\ SiO_2,\ 4\ MgO)$ in high-limed Portland cement mixture, the calcium silicate was fused completely, while the Portland cement clinker showed no signs of being affected; the fused mass, however, was completely disintegrated to the finest dust and the analysis showed that yet calcium oxide had been extracted from the Portland cement mass and that calcium ortho-silicate had been formed.

If the fused silicates under consideration have a higher percentage of calcium oxide, for instance 48 per cent to 52 per cent, they become very difficult to flux, because calcium ortho-silicate is formed instead of akermanite. The analyses of *B* and *E* show such fused silicates.

B consists of: 5 Mol. SiO_2, 1 Mol. Al_2O_3 and 9 Mol. CaO.

Hence of gehlenite = $2\ SiO_2$, Al_2O_3, $3\ CaO$
and ortho-silicate = $3\ SiO_2$; $6\ CaO$

E consists of 75 parts by weight of melilite + 10,6 CaO + 19 gehlenite, or if we consider the component parts of melilite, of:

38,16 Akermanite } 17,02 SiO_2 = 2837 Mol.
10,60 CaO } 31,74 CaO = 5668 Mol.

and of: 55,84 gehlenite, hence of: 48,76 parts by weight of calcium ortho-silicate and 55,84 parts of gehlenite.

Akermanite and gehlenite fuse at about 1,200 deg. C.; calcium ortho-silicate, however, only at 2,080 deg. C.; hence the difficulty which arises in fusing too high-limed slags. Another peculiarity of such slags containing ortho-silicate in large amounts is their crumbling into dust. This is due to the transformation of the ortho-silicate into the γ modification at 675 deg. C., which is accompanied by an increase of volume of 10 per cent, as Messrs. Day and Shepherd have demonstrated. In the same way Portland cement disintegrates, if it is too low in lime, or if well-burnt Portland cement of a sufficient percentage of lime has been exposed to red heat for too long a time and hence the calcium oxide, which had been dissolved by the ortho-silicate, had an opportunity to disunite, thus forming free ortho-silicate. The formation of crystals, however, which we observe in these fused silicates, is of little interest to us. As crystalloids, the silicates are

* Abstracted from a paper read before the Association of German Portland Cement Manufacturers at Berlin, Germany.

of no value in the hydraulic hardening process. Only their possible dissociation and the separation of calcium oxide are points of interest, as will be proven in the following.

For the hydraulic hardening process of slags only their glasslike, their colloidal state, has to be considered, for in order to be in a position to form a hydraulic compound with lime solution the slag must be able to swell, that is to say, it must be able to "adsorb" water and to form a gel. (The words "gel" and "hydrogel" have been coined by Prof. Thomas Graham. They designate the dry state of a gelatinous or colloidal substance and that of the same substance more or less imbibed with water.)

You probably find it strange that I call glassy slag a colloid, but if you want to understand the nature of the hydraulic hardening process, you have to accept these views which I have been presenting for the last fifteen years. Even our common glass is a colloid, as the original investigator of the chemistry of colloids, Thomas Graham, taught forty-five years ago.

All the minerals of which I have spoken so far, with the exception of augite, I have obtained by fusion of blast furnace slags. From these they crystallized under the proper circumstances. By cooling quickly, I have converted them into the glasslike state. I then found that, with the exception of akermanite mixtures, every member of this series, that is to say, calcium, meta-silicate, gehlenite, melilite and anorthite, hardened with calcium hydrate.

The experiments with akermanite will be repeated, as I am not sure to have obtained sufficiently pure specimens of the glass $3\ SiO_2, 4\ CaO$. In this effort to produce the various slag minerals, especially in their glasslike state, I have been ably assisted by Dr. Passow.

All of these glassy products, excepting the akermanite mixture, show, upon combination with lime-water, a noticeable swelling. The amount of lime, however, which goes into combination during the formation of "hydrogels" is small, with the exception of anorthite.

Parts by Weight.		Parts by Weight. CaO.
100	meta-silicate glass combined with...	3,7
100	gehlenite glass	5,7
100	melilite glass	6,1
100	anorthite glass	13,4
100	akermanite glass	0,0
100	slag "F"	4,5

That slag *F* which is able to form 39 per cent of ortho-silicate in addition to 53.5 per cent of gehlenite, has combined only with 4.5 parts of calcium oxide, although it contains more gehlenite than the typical melilite *A*, is to be explained by the behavior of the ortho-silicate. This gives off 10 per cent of its calcium oxide to the water, as I have found on material which I owed to the courtesy of Dr. Schott. Messrs. Day and Shepherd found that the percentage of calcium oxide given off amounted to about 10 per cent of the ortho-silicate. Hence this means a still larger separation of calcium oxide. The calcium hydrosilicate which I obtained was $5\ SiO_2, 9\ CaO + aq.$, that of Messrs. Day and Shepherd $5\ SiO_2, 8.5\ CaO + aq.$

If the glassy slags *A* and *F* are gaged with water, they do not harden; but if we add to the water sodium hydroxide (from 4 to 7 per cent of the slag used), they harden perfectly and yet no sodium enters into combination with the hardened compound. How is this hardening to be explained? It is made possible by a reaction between the sodium hydroxide and the calcium sulphide, which form calcium hydrate and sodium sulphide; 72 parts by weight of calcium sulphide form 34 parts of calcium hydrate and 38 sodium sulphide. The slags *A* and *F*, therefore, yield from 4 to 7.7 per cent of calcium hydrate, and this amount is entirely sufficient to bring about the hardening.

Hence the glassy, water or air granulated, that is to say, quickly and completely cooled, slags with a sufficient percentage of calcium oxide are puzzuolanas, for they are silica compounds which form hydraulic cements upon combination with calcium hydrate. This covers the definition of puzzuolanas, which are natural or artificial silica compounds that are, so to speak, not yet saturated with lime, and consequently can swell with lime solution.

We have always to remember that colloids do not yield well-defined compounds in the manner to which we are accustomed from crystalloids.

In addition to the method of cooling slags so far referred to, the cooling process of similar blast furnace slags can be directed in such a way that they require no further admixture of calcium hydrate, but harden independently when gaged with water. This is a patented process worked out by Dr. Passow. It is based upon keeping in the course of the cooling process part of the slag sufficiently long at a temperature of from 700 deg. to 900 deg. C., so that it can dissociate, as previously described; that is to say, that gehlenite can be decomposed into anorthite and calcium oxide. By this process part of the calcium sulphide is transformed into calcium sulphate and calcium oxide, whereby sulphurous acid escapes. Thereby the slag becomes porous or spongy. It contains free lime, as a study of microscopic sections shows. The presence of free lime is likewise revealed by the energetic reaction with carbonic acid, upon which Dr. Passow has based an analytical method of determining the value of these slags.

If with the above-mentioned slags *A*, *C*, *D*, and *F* with from 46 to 56 per cent of gehlenite complete dissociation into anorthite and calcium oxide would take place, from 13 to 16 per cent of calcium oxide would become free. From this follows, that even a partial decomposition of gehlenite suffices in order to supply the calcium oxide needed for the hydraulic hardening process. Dr. Passow mixes, for instance, 60 parts by weight of glassy slag with 40 parts of porous, spongy slag. The 60 parts of glassy slag require only from 3 to 4 parts of calcium oxide for their hardening, which the 40 parts of dissociated slag can supply. I have made a thorough study of such slag mixtures, and by many years of experience I am able to say that from freshly made Passow cement, manufactured exclusively from glassy and foamy slags, excellent hydraulic cements of high strength can be obtained, but such slag mixtures will not stand aging or storage. The small amount of free lime in them is in so perfect a state of subdivision that it is soon converted into carbonate of lime by the influence of the moisture and carbonic acid of the atmosphere. After this is done self-hardening of this cement is out of the question, of course. Dr. Passow, therefore, had to search for a more stable source of lime. He found it in Portland cement. Now he mixes from 15 to 25 parts of Portland cement with from 75 to 85 parts of slag capable of hardening; that is to say, mainly glassy slag. This amount of Portland cement starts the hardening process; it thus acts as a catalysator. It gives off, as we know, from 3 to 5 parts of lime in the course of its hardening process, which become available for the slag and contribute to the hardening of the latter.

Such are the proceedings in the course of the hydraulic hardening process of the sufficiently high-limed calcium-alumina-silicates, the blast furnace slags, according to my experiments carried on for many years.

Now I am going to describe the phenomena due to swelling:

In this glass cylinder you see a gelatinous mass occupying about 180 cubic centimeters. It has been obtained by the swelling of 2 grammes of melilite. This had previously been fused to a vitreous clinker and afterward pulverized very finely. Then the two grammes of substance had been agitated with a concentrated lime-water solution. In consequence of this treatment they have combined with from 6 to 7 per cent of calcium oxide and a large amount of water. The specific gravity of melilite is 2.9. The two grammes of the powdered substance, therefore, originally occupied a space of about 0.7 cubic centimeter. Hence, by swelling, the substance has increased its volume more than 200 times. In the other vessel you observe the effect of lime-water on 3 grammes of powdered melilite. In this case I have succeeded in making swell almost all of the minute particles independent one from another, so that you may see what swelling will do under the most favorable circumstances. If you stir the contents of this flask, you plainly see every single little grain of the powdered silicate swelled to a gelatinous flake; such perfect swelling is made possible only in fluids where expansion is unhindered. The substance has to be agitated continuously in the beginning, and thus to be kept in suspension, lest the grains in contact one with another interlock, stick together and harden; if this has been neglected from the start, it is impossible to separate the particles of the consolidated mass even by the most violent shaking.

How is this swelling to be explained?

I shall try to make this clear to you by an illustration. Imagine a bath sponge moistened and then compressed as much as possible and in this shape perfectly dried; it now occupies a very small space. If put in water and swelled completely, it will increase its volume 50 or 100 times.

In the same condition you must imagine to be the grains of granulated slag, of fused or vitrified cement, and in general of all hydraulic compounds. The water penetrates into the honeycombed mass by osmotic diffusion and fills the cells. The walls of the cells distend as the pressure increases. In this manner the "hydrogel," the water-saturated gelatinous mass, is formed. In the same way as the sponge can be compressed by expulsion of all of the absorbed water, the hydrogel of Portland or slag cement and of any hydraulic compound can be compressed to a solid body by expulsion of the water.

In metaphysics this state of matter is called a submicroscopic foam; chemists designate it as a gelatinous substance, as a colloid. We know more or less liquid colloids and even solid colloids. Only liquid foam-lamellæ have cell walls which make osmotic diffusion possible, and which can swell and permit of unhindered exchange of substances; that is to say, of complete reactions. Solidified colloids, the walls of which have been transformed into solids, are an obstacle to the free exchange of liquids, make reactions difficult, and finally with increasing hardening become perfectly impervious to liquids. Silica in the form of flint is the best example of a completely impenetrable hardened colloid.

Upon the existence of the hardening and solidifying colloids, created during the hardening process of all calcareous hydraulic cements, depends their durability in water; the formation of a solidified colloid as the chief element of the hydraulic cements is the characteristic and the only essential feature of the hydraulic hardening process. Whenever free silica partly uncombined, as is the case in puzzuolanas and slags, comes in contact with lime (calcium oxide) and water, or when water acts upon silica oversaturated with lime, as in Portland cement, colloids are formed, and it is of no consequence whether there are 1, 2, 3, 4, 5 or 6 molecules of calcium oxide present for each 4 molecules of silica; in all cases colloidal calcium hydro-silicate is formed. The amount of lime surpassing 6 molecules of calcium oxide is in the beginning enveloped in the colloids as colloidal calcium poly-hydrate, but mostly crystallizes later as calcium mono-hydrate. The more lime combines with the silica, the more firmly the colloids solidify, as a rule. Any modification of silica forms calcium hydrosilicate when in contact with calcium hydrate, even quartzy silica, which latter, as you know, has to be heated to over 90 deg. Centigrade in order to facilitate the reaction. Iron oxide and to some extent also alumina act in a similar way, but are not necessarily required for the formation of a hydraulic cement; calcium oxide, silica and water suffice for this purpose.

For everyone who does not wish to go very deeply into this study of the hydraulic hardening process it is only necessary to remember this reaction; the formation of the calcium hydro-silicate gel is the cardinal point of the hardening process of all calcareous hydraulic cements.

Now the question presents itself: How can a colloid harden in water? In the air, by drying out, this is feasible; but in water, how is that to be explained?

Very voluminous swelled colloids, hydrogels containing large amounts of water, can contract even in water, but will hardly petrify in water. Besides, it is a wrong conception to imagine a swelled colloid always to be a soft substance. This idea has certainly originated from our calling in every-day language soft semi-liquid substances gelatinous substances.

How solid and hard or how soft the gel is entirely depends upon the degree of swelling.

If pulverized Portland cement is gaged with an equal volume of water and left to rest, we obtain by water-absorption a mass swelled only so far as the volume of the paste permits, for the grains of the pulverized cement stick one to another, and this interferes with their individual expansion; as a result of this, the mass consolidates. Or if we carefully pour the cement into water, the water penetrates into the interstices and is absorbed by the cement; the grains begin to swell and immediately stick to one another. By osmotic diffusion water can enter the cement only until equilibrium of pressure is obtained. As soon as all interstices are filled by swelling, further admission of water is made impossible, the gel has become impervious to water. Only if the grains of the powdered cement are free and unhindered, for instance, if they are kept in suspension by continuous agitation of the water, and if they are thus not influenced one by another, they can swell perfectly and can form a very voluminous, soft hydrogel.

About forty-six years ago experiments of this nature induced Frederick Ransome to manufacture artificial sandstone from sodium silicate and calcium chloride solutions and from sand or crushed minerals. Thirty-three years ago I described his process in a paper read before this society. I am going to repeat a few paragraphs of this paper in order to recall Ransome's process to your memory:

"On the 9th of April, 1861, the first patent was granted to him, which was mainly based upon molding in forms a mixture of powdered chalk, with or without admixture of sand, and sodium silicate and following coating and hardening by means of a calcium salt solution.

"After some practical experience a more effective impregnation by means of attenuated air instead of absorption or coating was found necessary. Upon this an additional patent was based.

"In the following I will briefly describe the process of manufacture: The raw materials are sand, sodium hydroxide, calcium chloride and soluble silica, infusorial earth or flint. Sharp quartz sand, which must be as pure as possible, is cleaned by careful washing from all loose and loamy particles, then dried and afterward graded by sifting. The sodium silicate is manufactured from flint and concentrated sodium hydroxide in boilers at a pressure of from 4 to 6 atmospheres. The raw materials are added in such

quantities that a very concentrated solution ensues. The silicate solution is passed into settling tanks, where it is clarified. From these tanks it is drawn, ready to be mixed with the necessary ingredients and to be molded. It has the consistency of jelly and represents pure sodium silicate. The mixing of the silicate and sand, or a substance that takes the latter's place, for instance, pumice stone, glass, and so forth, according to the effect desired, is done very carefully and thoroughly by means of edge-runners. In this process the sand is further reduced in size and intimately mixed with the sodium silicate. Thus a plastic dough is formed consisting of sodium silicate and quartz, which is tamped or pressed into molds of plaster, wood or cast iron.

"The taking out of the forms requires some skill, since the mass possesses only limited cohesion; yet the cohesion is sufficient to make it possible to transport good-sized pieces if handled by experienced men. After having dried for some time, the blocks are placed into a calcium chloride solution. In this bath they are supported in such a way that they are completely submerged and that as much of their surface as possible is exposed to the surrounding liquid. In order to facilitate the penetration of the calcium chloride solution a powerful air-pump is used, which, by means of suction disks with numerous openings, draws the air out of the block. Large pieces are preferably made hollow in order to enable the solution to penetrate to the center. The reaction between calcium chloride and sodium silicate sets in immediately. After having passed through this process, the blocks are placed into a hot calcium chloride solution in order to make the chemical combination more perfect, if this is possible, for they possess already a considerable strength upon leaving the first bath.

"All that remains to do is to wash out the alkali-chloride resulting from the action of calcium chloride upon sodium silicate. This is a rather tedious process, especially in the case of large blocks. Where pure, running water is to be had in abundance, it suffices to leave the blocks long enough in the water. Otherwise, they are placed in 'rain chambers,' in which they are continuously sprayed for days and weeks, according to the size of the piece. Water containing iron must be carefully avoided in this process, because this would discolor the artificial stone by forming iron hydroxide, which can be formed as long as alkali-hydroxide or carbonate is left in the block.

"Experience has shown that also with this cement the strength increases with age, for the calcium hydro-silicate, which causes the adherence of the sand grains, represents the cement. The experiments which I have made date back only to September of last year (1873).

"The tensile strength of test pieces made from coarse sand was:

After 14 days, 510 pounds per square inch.
After 60 days, 640 pounds per square inch.
After 120 days, 800 pounds per square inch.

"These figures represent in each case the average of ten briquettes which were kept in air.

"However, this process had one very weak point. The colloid which formed was so solid and dense that it made the completion of the process extremely difficult. With large blocks the calcium chloride solution could not penetrate to the center. Notwithstanding the application of rarefied air, the sodium silicate in the center of the piece could not be reached by the calcium chloride solution. On the other hand, even if perfect reaction were made possible and the piece had been hardened to the center, the sodium chloride could not be washed out even after continued washing for weeks and months."

This process, therefore, proved to be uneconomical. In the summer of 1873, when I started the first Swedish Portland cement plant at Lomma, I became acquainted with this Ransome process for the manufacture of artificial stone at the works of Julius Erichsen at Saltholm, Copenhagen. There I learned to appreciate the advantages and disadvantages of this process. My subsequent efforts of devising a method which would be free of the objections adhering to Ransome's process led me to the invention of the high-pressure hardening process. But by the time I had this process worked out, and a patent was granted to me in 1880, Julius Erichsen and Frederick Ransome were at the end of their experiments. My friend Erichsen was utterly discouraged. Thus it happened that my process remained unused. You know that it took a long time before it was appreciated. I am, unfortunately, not an exploiter.

(To be concluded.)

Detection of Cocoa Butter in Butter and Lard.—The presence of cocoa butter as an adulterant in butter or lard can be detected by means of the differences in the boiling points of the ethyl esters obtained from the three fats, or by the different degrees of solubility of the corresponding fatty acids in 60 per cent alcohol. The latter method is the simpler in practice and should be employed first, the other method being reserved for confirmation of the results in special cases.

ENGINEERING NOTES.

A gas producer for the use of pulverized fuel consists of a receiver, circular in plan, lined with refractory material. Near the bottom and almost tangential to the circumference of the lining is inserted the discharge pipe of a fan blower by means of which the pulverized fuel, together with the requisite quantity of air, is introduced. The producer is started by making a wood fire and then blowing in the coal dust by means of the fan. A very high temperature is produced which slags much of the ash, which is withdrawn every six or eight hours, this being the only cleaning required. Owing to the high temperature the tar is converted into gas. The largest plant at present using this system yields 600 horse-power continuously from an inferior quality of coal.—Le Genie Civil.

The report that the German South-West Africa Company has obtained a concession from the Portuguese government for the construction of a railway from Fort Alexander, in Southern Angola, to the frontier of the German protectorate, and is now negotiating with the German government for a kilometric guarantee for the continuation of the line a further 750 miles through German territory, to reach Johannesburg, the proposed terminal of the line, is unfavorably criticised by the German press. It is declared that the South-West Africa Company employs only British officials on the newly-built Otari-Grootfontein Railway, and purchases all its materials in Great Britain. It is proposed that opposition shall be made to a line through a German colony built with non-German material and run by foreign officials.

The pulling capacity of any locomotive, as has been well said, is governed largely by its weight, as the weight bears a direct relation to the ratio of adhesion, which in steam locomotives for freight service is usually about 1 to 4½ or 5, while with passenger locomotives it is usually about 1 to 5. The amount of tonnage, or weight of train that a locomotive will start depends on a number of things, principally, the tractive power of the engine; the condition of the rail has much to do with this, and in the matter of the speed of trains the size of the boiler and the relative ratio between cylinder volume, heating surface, evaporating surface and grate area are all controlling factors in the efficiency of the machine, and, therefore, govern its performance. The type of steam locomotive in most common use has a less starting efficiency than an electric locomotive of the same weight for the reason that the torque or turning moment of the electric locomotive is maximum and constant at all points, and at all times, while the steam locomotive referred to, has dead points, which affects its efficiency or power. This principle is very clearly shown in the improved steam locomotive of the four-cylinder balanced type, which provides a more constant turning moment, or torque, which approaches very closely to the efficiency of an electric locomotive in the matter of starting from a period of rest. The question of efficiency to move trains of a given weight over a certain distance, however, is governed entirely by the size of the boiler, and its ability to provide steam for this purpose. The limitation of a steam locomotive is, therefore, fixed and determined by the size of its boiler, while that of an electric locomotive is governed by the power plant where the electricity is generated for its propulsion.

A test was made recently at the Springfield armory of the noiseless rifle invented by Hiram Percy Maxim. The test demonstrated that the report of a service army rifle was so reduced by the device as to be inaudible at a distance of 150 feet from the person firing. The invention is of a nature similar to the muffler of a gas engine. Its essential parts are a valve that closes the bore of the gun immediately after the projectile has passed the valve. This closure of the valve prevents the sudden expansion of the gases, the gases being emitted slowly. The result is that the characteristic report of a rifle is reduced three-fourths in loudness, it being judged by the officials who were present that the efficiency of the apparatus was about 74 per cent. In the report of the test it is stated that upon firing, the report was like the snapping of one's fingers accompanied by a slight hissing as the gases escaped. The sound of the hammer striking the firing pin was much sharper than the report of the piece. The invention appears to be entirely practicable and it is thought that it will work a revolution in warfare. The firing line of an army equipped with noiseless and smokeless rifles will be very hard to locate, as there will be neither noise nor smoke to guide the observer as to the position of the enemy. A dangerous feature of the new weapon is that it lends itself admirably to the cowardly assassin. With a noiseless gun it will be possible to shoot down a man in the street without alarming the police. On the other hand, as a game gun the new rifle will be highly prized, it being possible with it to shoot an animal without scaring the remainder of the herd, but even that has its drawback, as it will tend to make the business of pot-hunting more successful.—Machinery.

TRADE NOTES AND FORMULÆ.

To prevent the drying out of gum Arabic, it is only necessary to place a small piece of camphor in the solution. The gum is not thereby impaired but remains adhesive to the last drop. Another method is to add a small addition of glycerine.

Bright Gold Ink for Wash Clothes.—I. 1 part of chloro-aurate of sodium, 10 parts of water, 2 parts of gum. II. 1 part of oxalic acid, 5 parts of water, 2 parts of gum. The fabric on which the writing is to appear is prepared with the second fluid, the dried spot written on with the first described ink, smoothed under heavy pressure and then washed out.

Glycerine Dressing (Maudot's).—Take 500 parts of white, soluble dextrine, 1,200 parts of glycerine of 28 deg. Bé., 100 parts of sulphate of alumina, and 3,000 parts of river water. The water is heated to boiling and the glycerine added gradually; after the boiling has been continued for a few minutes, the fluid is taken from the fire in order to dissolve in it the sulphate of alumina and to mix it with the glycerine. After cooling, it is filled into bottles for keeping; 150 parts of this preparation, to which has been added 250 parts of glue, previously dissolved in 3,000 parts of water, is sufficient for the weaving of 100 yards of muslin.

Fly paper (sticky) is obtained by coating parchment paper, or such as contains alum, with fly glue, made according to the following recipes:

Rosin	550	500	650	600	500
Linseed oil	350	300	...	...	...
Castor oil	...	...	350	300	340
Honey	100	200	...	100	...
Glycerin	...	...	...	...	160

The glue is applied to the paper, in a warm fluid condition, with the help of a brush. To expedite the killing of the insects, we can incorporate with the honey, strong decoctions of pepper or quassia or tartar emetic.

Glyphogene etching fluid for steel consists of the preliminary etching fluid, the rinsing fluid and the etching fluid proper. The preliminary etching fluid is made of 95 parts of water, 5 parts of chemically pure nitric acid and some spirits of wine, and is allowed to work for only a few minutes. The objects treated with the preliminary etching fluid are rinsed off with the rinsing fluid (consisting of distilled water and one-third the volume of spirits of wine) and quickly dried with the aid of the bellows; the etching fluid (30 parts distilled water, 15 parts spirits of wine, 6 parts of chemically pure nitric acid and half a part of crystallized nitrate of silver) is poured on to a depth of ⅜ of an inch.

Spot-eradicating liquid (Francois's) is made from 64 parts each of dried soap wort root and dried soap wort, 45 parts of clarified lemon juice, 185 parts of spirits of wine of 34 deg. test, and 1,700 parts of pure river water. The root, coarsely pulverized, should be boiled for a quarter of an hour, then the finely chopped leaves added and heated to boiling for another 20 minutes, then strained, filtered and allowed to cool. Meanwhile, the lemon juice is added separately to the alcohol and the whole mixed with the soap wort decoction. It is used cold, or still better luke-warm, the spot being dipped into it; in the case of silk goods, it should be rubbed to a lather with the hand, cotton and linen fabrics should be scrubbed with a brush. Then rinse in clean water and press.

Eau Seconde.—Under this designation are recognized various mixtures used for cleaning paintings. 1. According to Lukanus, equal parts of alcohol of 90 per cent and oil of turpentine. To moderate its solvent property, take perhaps a little more oil of turpentine, with a small addition of poppy seed oil and copaiba balsam. By means of honey and egg yolk the cleaning fluid is made more homogeneous and more perfect combination of the oils with alcohol or with water is promoted. For more rapidly-solvent cleansing fluid, mix 2 parts of 90 per cent alcohol with 1 part of lemon oil, lavender oil, clove oil, or rosemary oil. 2. According to Liebig. A mixture of 4 parts of caustic spirits of sal ammoniac, 2 parts of refined potash, and 100 parts of distilled water. In case the mixtures appear to actively effect the colors it is advisable to pour on some diluted vinegar to neutralize them.

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